COMPAQ

Parallel Database Cluster Model PDC/O5000 for Oracle8*i* and Windows 2000

Administrator Guide

Second Edition (June 2001)
Part Number 225081-002
Compaq Computer Corporation

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Parallel Database Cluster Model PDC/05000 for Oracle8*i* and Windows 2000
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About This Guide

Purpose

This administrator guide provides information about the planning, installation, configuration, implementation, management, and troubleshooting of the Compaq Parallel Database Cluster Model PDC/O5000 on Oracle8*i* software running on the Microsoft Windows 2000 Advanced Server operating system.

Audience

The expected audience of this guide consists primarily of MIS professionals whose jobs include designing, installing, configuring, and maintaining Compaq Parallel Database Clusters.

The audience of this guide must have a working knowledge of Microsoft Windows 2000 Advanced Server and Oracle databases or have the assistance of a database administrator.

This guide contains information for network administrators, database administrators, installation technicians, systems integrators, and other technical personnel in the enterprise environment for the purpose of cluster planning, installation, implementation, and maintenance.

IMPORTANT: This guide contains installation, configuration, and maintenance information that can be valuable for a variety of users. If you are installing the PDC/O5000 but will not be administering the cluster on a daily basis, please make this guide available to the person or persons who will be responsible for the clustered servers after you have completed the installation.

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Scope

This guide offers significant background information about clusters as well as basic concepts associated with designing clusters. It also contains detailed product descriptions and installation steps.

This administrator guide is designed to assist you in the following objectives:

- Understanding basic concepts of clustering technology
- Recognizing and using the high-availability features of the PDC/O5000
- Planning and designing a PDC/O5000 cluster configuration to meet your business needs
- Installing and configuring PDC/O5000 hardware and software
- Managing the PDC/O5000
- Troubleshooting the PDC/O5000

The following summarizes the contents of this guide:

- Chapter 1, "Clustering Overview," provides an introduction to clustering technology features and benefits.
- Chapter 2, "Cluster Architecture," describes the hardware components of the PDC/O5000 and provides detailed I/O path configuration information.
- Chapter 3, "Cluster Software Components," describes software components used with the PDC/O5000.
- Chapter 4, "Cluster Planning," outlines an approach to planning and designing cluster configurations that meet your business needs.
- Chapter 5, "Installation and Configuration," outlines the steps you will take to install and configure the PDC/O5000 hardware and software.
- Chapter 6, "Cluster Management," includes techniques for managing and maintaining the PDC/O5000.
- Chapter 7, "Troubleshooting," contains troubleshooting information for the PDC/O5000.
- Appendix A, "Diagnosing and Resolving Shared Disk Problems," describes procedures to diagnose and resolve shared disk problems.
- Glossary contains definitions of terms used in this guide.

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Some clustering topics are mentioned, but not detailed, in this guide. For example, this guide does not describe how to install and configure Oracle8*i* on a cluster. For information about these topics, see the referenced and supplemental documents listed in subsequent sections.

Referenced Manuals

For additional information, refer to documentation related to the specific hardware and software components of the Compaq Parallel Database Cluster. These related manuals include, but are not limited to:

- Documentation related to the ProLiant servers you are clustering (for example, guides, posters, and performance and tuning guides)
- Compaq StorageWorks documentation provided with the MA8000/EMA12000 Storage Subsystem, HSG80 Array Controller, Fibre Channel SAN Switches, Storage Hubs, and the KGPSA-BC or KGPSA-CB Host Adapter
- Microsoft Windows 2000 Advanced Server documentation
  - *Microsoft Windows 2000 Advanced Server Administrator's Guide*
- Oracle8*i* documentation, including:
  - *Oracle8i Parallel Server Setup and Configuration Guide*
  - *Oracle8i Parallel Server Concepts*
  - *Oracle8i Parallel Server Administration, Deployment, and Performance*
  - *Oracle Enterprise Manager Administrator's Guide*
  - *Oracle Enterprise Manager Configuration Guide*
  - *Oracle Enterprise Manager Concepts Guide*

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Supplemental Documents

The following technical documents contain important supplemental information for the Compaq Parallel Database Cluster Model PDC/O5000:

- *Compaq Parallel Database Cluster Model PDC/O5000 Certification Matrix for Windows 2000*, at

  www.compaq.com/solutions/enterprise/ha-pdc.html

- *Configuring Compaq RAID Technology for Database Servers*, at

  www.compaq.com/highavailability

- Various technical white papers on Oracle and cluster sizing, which are available from Compaq ActiveAnswers website, at

  www.compaq.com/activeanswers

Text Conventions

This document uses the following conventions to distinguish elements of text:

Keys	Keys appear in boldface. A plus sign (+) between two keys indicates that they should be pressed simultaneously.
USER INPUT	User input appears in a different typeface and in uppercase.
FILENAMES	File names appear in uppercase italics.
Menu Options, Command Names, Dialog Box Names	These elements appear in initial capital letters, and may be bolded for emphasis.
COMMANDS, DIRECTORY NAMES, and DRIVE NAMES	These elements appear in uppercase.
Type	When you are instructed to *type* information, type the information **without** pressing the **Enter** key.
Enter	When you are instructed to *enter* information, type the information and then press the **Enter** key.

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Symbols in Text

These symbols may be found in the text of this guide. They have the following meanings:

WARNING: Text set off in this manner indicates that failure to follow directions in the warning could result in bodily harm or loss of life.

CAUTION: Text set off in this manner indicates that failure to follow directions could result in damage to equipment or loss of information.

IMPORTANT: Text set off in this manner presents clarifying information or specific instructions.

NOTE: Text set off in this manner presents commentary, sidelights, or interesting points of information.

Symbols on Equipment

These icons may be located on equipment in areas where hazardous conditions may exist.

Any surface or area of the equipment marked with these symbols indicates the presence of electrical shock hazards. Enclosed area contains no operator serviceable parts.
WARNING: To reduce the risk of injury from electrical shock hazards, do not open this enclosure.

Any RJ-45 receptacle marked with these symbols indicates a Network Interface Connection.
WARNING: To reduce the risk of electrical shock, fire, or damage to the equipment, do not plug telephone or telecommunications connectors into this receptacle.

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Any surface or area of the equipment marked with these symbols indicates the presence of a hot surface or hot component. If this surface is contacted, the potential for injury exists.

WARNING: To reduce the risk of injury from a hot component, allow the surface to cool before touching.

Power Supplies or Systems marked with these symbols indicate the equipment is supplied by multiple sources of power.

WARNING: To reduce the risk of injury from electrical shock, remove all power cords to completely disconnect power from the system.

Rack Stability

WARNING: To reduce the risk of personal injury or damage to the equipment, be sure that:

- The leveling jacks are extended to the floor.
- The full weight of the rack rests on the leveling jacks.
- The stabilizing feet are attached to the rack if it is a single rack installations.
- The racks are coupled together in multiple rack installations.
- Only one component is extended at a time. A rack may become unstable if more than one component is extended for any reason.

Getting Help

If you have a problem and have exhausted the information in this guide, you can get further information and other help in the following locations.

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Compaq Technical Support

You are entitled to free hardware technical telephone support for your product for as long you own the product. A technical support specialist will help you diagnose the problem or guide you to the next step in the warranty process.

In North America, call the Compaq Technical Phone Support Center at 1-800-OK-COMPAQ[1]. This service is available 24 hours a day, 7 days a week.

Outside North America, call the nearest Compaq Technical Support Phone Center. Telephone numbers for world wide Technical Support Centers are listed on the Compaq website. Access the Compaq website by logging on to the Internet at

www.compaq.com

Be sure to have the following information available before you call Compaq:

- Technical support registration number (if applicable)
- Product serial number(s)
- Product model name(s) and numbers(s)
- Applicable error messages
- Add-on boards or hardware
- Third-party hardware or software
- Operating system type and revision level
- Detailed, specific questions

Compaq Website

The Compaq website has information on this product as well as the latest drivers and Flash ROM images. You can access the Compaq website by logging on to the Internet at

www.compaq.com

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[1] For continuous quality improvement, calls may be recorded or monitored.

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Compaq Authorized Reseller

For the name of your nearest Compaq Authorized Reseller:

- In the United States, call 1-800-345-1518.
- In Canada, call 1-800-263-5868.
- Elsewhere, see the Compaq website for locations and telephone numbers.

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Chapter 1

Clustering Overview

For many years, companies have depended on clustered computer systems to fulfill two key requirements: to ensure users can access and process information that is critical to the ongoing operation of their business, and to increase the performance and throughput of their computer systems at minimal cost. These requirements are known as *availability* and *scalability*, respectively.

Historically, these requirements have been fulfilled with clustered systems built on proprietary technology. Over the years, open systems have progressively and aggressively moved proprietary technologies into industry-standard products. Clustering is no exception. Its primary features, availability and scalability, have been moving into client/server products for the last few years.

The absorption of clustering technologies into open systems products is creating less expensive, non-proprietary solutions that deliver levels of function commonly found in traditional clusters. While some uses of the proprietary solutions will always exist, such as those controlling stock exchange trading floors and aerospace mission controls, many critical applications can reach the desired levels of availability and scalability with non-proprietary client/server-based clustering.

These clustering solutions use industry-standard hardware and software, thereby providing key clustering features at a lower price than proprietary clustering systems. Before examining the features and benefits of the Compaq Parallel Database Cluster Model PDC/O5000 (referred to here as the PDC/O5000), it is helpful to understand the concepts and terminology of clustered systems.

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Clusters Defined

A cluster is an integration of software and hardware products that enables a set of loosely coupled servers and shared storage subsystem components to present a single system image to clients and to operate as a single system. As a cluster, the group of servers and shared storage subsystem components offers a level of availability and scalability far exceeding that obtained if each cluster node operated as a stand-alone server.

The PDC/O5000 uses the Oracle8*i* Parallel Server software, which is a parallel database that can distribute its workload among the cluster nodes. Refer to Chapter 3, "Cluster Software Components" to determine the specific releases your cluster kit supports.

Figure 1-1 shows an example of a PDC/O5000 that includes two nodes (Compaq *ProLiant*™ servers), two sets of storage subsystems, two Compaq *StorageWorks*™ Fibre Channel SAN Switches or Compaq StorageWorks Fibre Channel Storage Hubs, a redundant cluster interconnect, and a client local area network (LAN).

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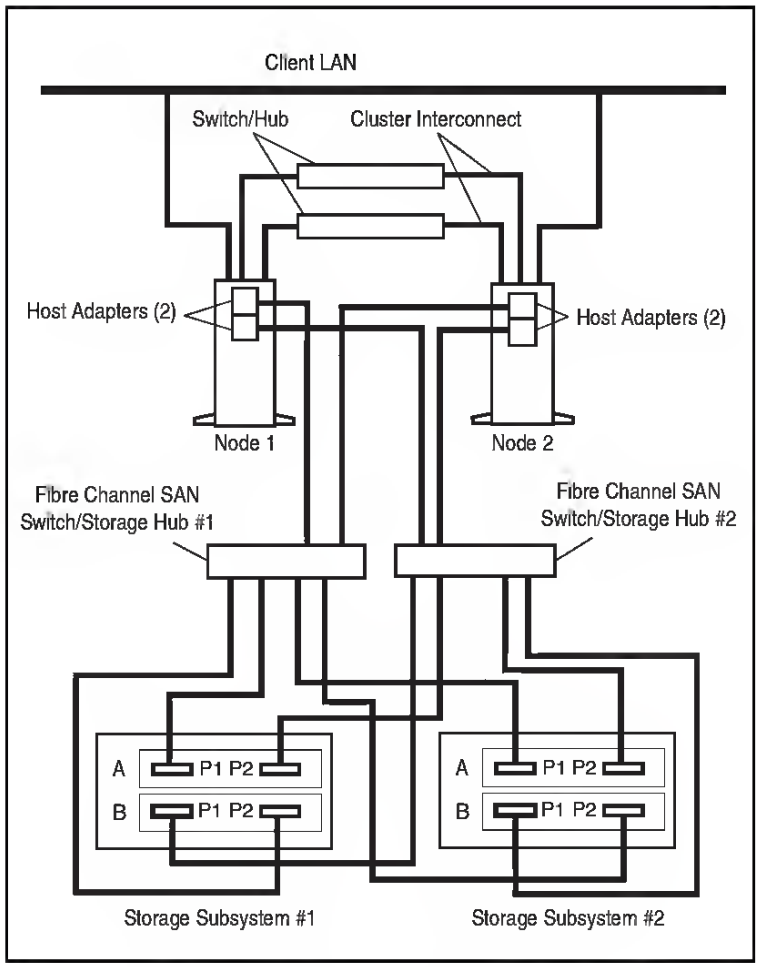

Figure 1-1. Example of a two-node PDC/O5000 cluster

The PDC/O5000 can support redundant Fibre Channel Fabric Storage Area Network (SAN) and redundant Fibre Channel Arbitrated Loop (FC-AL) SAN topologies. In the example shown in Figure 1-1, the clustered nodes are connected to the database on the shared storage subsystems through a redundant Fibre Channel Fabric or redundant FC-AL. Clients access the database through the client LAN, and the cluster nodes communicate across an Ethernet cluster interconnect.

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Availability

When computer systems experience outages, the amount of time the system is unavailable is referred to as *downtime*. Downtime has several primary causes: hardware faults, software faults, planned service, operator error, and environmental factors. Minimizing downtime is a primary goal of a cluster.

Simply defined, *availability* is the measure of how well a computer system can continuously deliver services to clients.

Availability is a system-wide endeavor. The hardware, operating system, and applications must be designed for availability. Clustering requires stability in these components, then couples them in sucb a way that failure of one item does not render the system unusable. By using redundant components and mechanisms that detect and recover from faults, clusters can greatly increase the availability of applications critical to business operations.

Scalability

Simply defined, *scalability* is a computer system characteristic that enables improved performance or throughput when supplementary hardware resources are added. Scalable systems allow increased throughput by adding components to an existing system without the expense of adding an entire new system.

In a stand-alone server configuration, scalable systems allow increased throughput by adding processors or more memory. In a cluster configuration, this result is usually obtained by adding cluster nodes.

Not only must the hardware benefit from additional components, but also software must be constructed in such a way as to take advantage of the additional processing power. Oracle8*i* Parallel Server distributes the workload among the cluster nodes. As more nodes are added to the cluster, cluster-aware applications can use the parallel features of Oracle8*i* Parallel Server to distribute workload among more servers, thereby obtaining greater throughput.

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Compaq Parallel Database Cluster Overview

As traditional clustering technology has moved into the open systems of client/server computing, Compaq has provided innovative, customer-focused solutions. The PDC/O5000 moves client/server computing one step closer to the capabilities found in expensive, proprietary cluster solutions, at a fraction of the cost.

The PDC/O5000 combines the popular Microsoft Windows 2000 Advanced Server operating system and the industry-leading Oracle8*i* Parallel Server with award-winning Compaq ProLiant servers and shared storage subsystems.

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Chapter 2

Cluster Architecture

The Compaq Parallel Database Cluster Model PDC/O5000 (referred to here as the PDC/O5000) is an integration of a number of different hardware and software products. This chapter discusses how these products play a role in bringing a complete clustering solution to your computing environment.

The hardware products include:

- Compaq ProLiant servers
- Shared storage components
  - Compaq StorageWorks Modular Array 8000 Fibre Channel Storage Subsystems or the Compaq StorageWorks Enterprise Modular Array 12000 Fibre Channel Storage Subsystems (MA8000/EMA12000 Storage Subsystems)
  - Compaq StorageWorks HSG80 Array Controllers (HSG80 Array Controllers)
  - Compaq StorageWorks Fibre Channel SAN Switches (Fibre Channel SAN Switches) for redundant Fibre Channel Fabrics
  - Compaq StorageWorks Storage Hubs (Storage Hubs) for redundant Fibre Channel Arbitrated Loops
  - KGPSA-BC PCI-to-Optical Fibre Channel Host Adapters (KGPSA-BC Host Adapters) or KGPSA-CB PCI-to-Optical Fibre Channel Host Adapters (KGPSA-CB Host Adapters)

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  - Gigabit Interface Converter-Shortwave (GBIC-SW) modules
  - Fibre Channel cables
- Cluster interconnect components
  - Ethernet NIC adapters
  - Ethernet cables
  - Ethernet switches/hubs

The software products include:

- Microsoft Windows 2000 Advanced Server with Service Pack 1 or later
- Compaq drivers and utilities
- Oracle8*i* Enterprise Edition with the Oracle8*i* Parallel Server Option

For a description of the software products used with the PDC/O5000, refer to Chapter 3, "Cluster Software Components."

Compaq ProLiant Servers

A primary component of any cluster is the server. Each Compaq Parallel Database Cluster Model PDC/O5000 consists of cluster nodes in which each node is a Compaq ProLiant server.

With some exceptions, all nodes in a PDC/O5000 must be identical in model. In addition, all components common to all nodes in a cluster, such as memory, number of CPUs, and the interconnect adapters, should be identical and identically configured.

NOTE: Certain restrictions apply to the server models and server configurations that are supported by the Compaq Parallel Database Cluster. For a current list of PDC-certified servers and details on supported configurations, refer to the *Compaq Parallel Database Cluster Model PDC/O5000 Certification Matrix for Windows 2000*. This document is available on the Compaq website at

www.compaq.com/solutions/enterprise/ha-pdc.html

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High-Availability Features of ProLiant Servers

In addition to the increased application and data availability enabled by clustering, ProLiant servers include many reliability features that provide a solid foundation for effective clustered server solutions. The PDC/O5000 is based on ProLiant servers, most of which offer excellent reliability through redundant power supplies, redundant cooling fans, and Error Checking and Correcting (ECC) memory. The high-availability features of ProLiant servers are a critical foundation of Compaq clustering products. Table 2-1 lists the high-availability features found in many ProLiant servers.

Table 2-1
High-Availability Components of ProLiant Servers

Hot-pluggable hard drives	Redundant power supplies
Digital Linear Tape (DLT) Array (optional)	ECC-protected processor-memory bus
Uninterruptible power supplies (optional)	Redundant processor power modules
ECC memory	PCI Hot Plug slots (in some servers)
Offline backup processor	Redundant cooling fans

Shared Storage Components

The PDC/O5000 is based on a cluster architecture known as shared storage clustering, in which clustered nodes share access to a common set of shared disk drives. In this discussion, the shared storage includes these components:

- MA8000/EMA12000 Storage Subsystem
- HSG80 Array Controllers
- Fibre Channel SAN Switches for redundant Fibre Channel Fabrics
- Storage Hubs for redundant Fibre Channel Arbitrated Loops
- KGPSA-BC or KGPSA-CB Host Adapters
- Gigabit Interface Converter-Shortwave (GBIC-SW) modules
- Fibre Channel cables

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MA8000/EMA12000 Storage Subsystem

The MA8000/EMA12000 Storage Subsystem is the shared storage solution for the PDC/O5000. Each storage subsystem consists of one controller enclosure and up to six disk enclosures.

For detailed information about storage subsystem components, refer to the Compaq StorageWorks documentation provided with the MA8000/EMA12000 Storage Subsystem.

Controller Enclosure Components

The controller enclosure for the MA8000/EMA12000 Storage Subsystem houses the two HSG80 Array Controllers, one cache module for each controller, an environmental monitoring unit (EMU), one or two power supplies, and three dual-speed fans. In addition, the controller enclosure houses the six I/O modules that connect the enclosure's six SCSI buses to up to six disk enclosures.

Disk Enclosure Components

Each disk enclosure houses up to 12 or 14 form factor hard disk drives, depending on the number of SCSI buses connected to the enclosure's I/O module. A single-bus or dual-bus I/O module in each disk enclosure is connected by UltraSCSI cable to one single-bus I/O module in the controller enclosure. Disk enclosures using a single-bus I/O module can contain up to 12 disk drives. Disk enclosures using both connectors on a dual-bus I/O module can contain up to 14 disk drives (7 per SCSI bus). When you have more than three disk enclosures in your subsystem, they must all use single-bus I/O modules, for a maximum of 72 disk drives in each MA8000/EMA12000 Storage Subsystem.

Each disk enclosure also contains redundant power supplies, an EMU, and two variable-speed blowers.

HSG80 Array Controller

Two dual-port HSG80 Array Controllers are installed in the controller enclosure of each MA8000/EMA12000 Storage Subsystem.

From the perspective of the cluster nodes, eacb HSG80 Array Controller port is simply another device connected to one of the cluster's I/O connection paths between the host adapters and the MA8000/EMA12000 Storage Subsystems. Consequently, each node sends its I/O requests to the array controllers just as

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it would to any SCSI device. An array controller port receives the I/O requests from a host adapter in a cluster node and directs them to the shared storage disks to which it has been configured.

Because the array controller processes the I/O requests, the cluster nodes are not burdened with the I/O processing tasks associated with reading and writing data to multiple shared storage devices.

Each HSG80 Array Controller port combines all of the logical disk drives that have been configured to it into a single, high-performance storage unit called a storageset. RAID technology ensures that every unpartitioned storageset, whether it uses 12 disks or 14 disks, looks like a single storage unit to the cluster nodes.

Both ports on each of the two HSG80 Array Controllers in the controller enclosure are simultaneously active, and access to a specific logical unit number (LUN) is distributed among and shared by these ports. This provides redundant access to the same LUNs if one port or array controller fails. If an HSG80 Array Controller in an MA8000/EMA12000 Storage Subsystem fails, Secure Path failover software detects the failure and automatically transfers all I/O activity to the defined backup path.

To further ensure redundancy, connect the two ports on each HSG80 Array Controller by Fibre Channel cables to different Fibre Channel SAN Switches or Storage Hubs.

For further information, refer to the Compaq StorageWorks documentation provided with the array controllers.

Fibre Channel SAN Switch

IMPORTANT: For detailed information about cascading two Fibre Channel SAN Switches, refer to the latest Compaq StorageWorks documentation. This guide does not document cascaded configurations for the Fibre Channel SAN Switch.

Fibre Channel SAN Switches are installed between cluster nodes and shared storage subsystems in clusters to create redundant Fibre Channel Fabrics.

An 8-port Fibre Channel SAN Switch and 16-port Fibre Channel SAN Switch are supported. From two to four Fibre Channel SAN Switches can be used in each redundant Fibre Channel Fabric.

Fibre Channel SAN Switches provide full 100 MBps bandwidth on every port. Adding new devices to Fibre Channel SAN Switch ports increases the aggregate bandwidth.

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For further information, refer to these manuals provided with each Fibre Channel SAN Switch:

- *Compaq StorageWorks Fibre Channel SAN Switch 8 Installation and Hardware Guide*
- *Compaq StorageWorks Fibre Channel SAN Switch 16 Installation and Hardware Guide*
- *Compaq StorageWorks Fibre Channel SAN Switch Management Guide provided with the Fibre Channel SAN Switch*

Storage Hub

Storage Hubs are installed between cluster nodes and shared storage subsystems in clusters to create redundant Fibre Channel Arbitrated Loops.

Storage Hubs connect the host adapters in cluster nodes with the HSG80 Array Controllers in MA8000/EMA12000 Storage Subsystems. From two to four Storage Hubs are used in each redundant FC-AL of a PDC/O5000. Using two or more Storage Hubs provides fault tolerance and supports the redundant architecture implemented by the PDC/O5000.

You can use either the Storage Hub 7 (with 7 ports) or the Storage Hub 12 (with 12 ports). Using the Storage Hub 7 may limit the size of the PDC/O5000. For more detailed information, refer to Chapter 4, "Cluster Planning," in this guide.

Refer to the *Compaq StorageWorks Fibre Channel Storage Hub 7 Installation Guide* and the *Compaq StorageWorks Fibre Channel Storage Hub 12 Installation Guide* for further information about the Storage Hubs.

KGPSA-BC and KGPSA-CB Host Adapter

Each redundant Fibre Channel Fabric or redundant FC-AL contains a dedicated set of KGPSA-BC or KGPSA-CB Host Adapters in every cluster node. Each host adapter in a node should be connected to a different Fibre Channel SAN Switch or Storage Hub.

If the cluster contains multiple redundant Fibre Channel Fabrics or multiple redundant FC-ALs, then host adapters cannot be shared between them. Each redundant Fibre Channel Fabric or redundant FC-AL must have its own set of host adapters installed in each cluster node.

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Compaq StorageWorks Secure Path failover software is installed on every cluster node to ensure the proper operation of components along each I/O path. For information about installing Secure Path, see the section entitled, "Installing Secure Path for Windows 2000" in Chapter 5, "Installation and Configuration."

Gigabit Interface Converter-Shortwave

A Gigabit Interface Converter-Shortwave (GBIC-SW) module is installed at both ends of a Fibre Channel cable. A GBIC-SW module must be installed in each host adapter, active Fibre Channel SAN Switch or Storage Hub port, and array controller.

GBIC-SW modules provide 100 MB/second performance. Fibre Channel cables connected to these modules can be up to 500 meters in length.

Fibre Channel Cables

Shortwave (multi-mode) fibre optic cables are used to connect the server nodes, Fibre Channel SAN Switches or Storage Hubs, and array controllers in a PDC/O5000.

Configuring and Cabling the MA8000/EMA12000 Storage Subsystem Components

Configuring LUNS for Storagesets

If you install the optional Compaq StorageWorks Large LUN utility on your PDC/O5000 cluster, you can distribute a maximum of 256 LUNs among the four array controller ports in each storage subsystem.

If you do not install the Large LUN utility, you can distribute a maximum of 16 LUNs among the four array controller ports in each storage subsystem. This 16-LUN restriction is imposed by the Compaq Secure Path software and the MA8000/EMA12000 Storage Subsystems.

IMPORTANT: When offsets are used, always assign LUNs 0-99 to port 1 on each HSG80 Array Controller and assign LUNs 100-199 to port 2.

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If you do not install the optional Large LUN utility in you cluster, there are two accepted methods for distributing LUNs for storagesets:

- You can distribute eight LUNs between the same-numbered ports on both array controllers so that a total of 16 LUNs are assigned across all four controller ports in each storage subsystem. For example, assign LUNs 0 through 3 to array controller A port 1, LUNs 4 through 7 to array controller B port 1, LUNs 100 through 103 to array controller A port 2, and LUNs 104 through 107 to array controller B port 2. If array controller A fails in multibus failover mode, Secure Path automatically gives controller B control over I/O transfers for LUNs 0-3 on port 1 and LUNs 100-103 on port 2.
- You can distribute eight LUNs across all four array controller ports. For example, assign LUNs 0 and 1 to array controller A port 1, LUNS 2 and 3 to array controller A port 2, LUNS 4 and 5 to array controller B port 1, and LUNs 6 and 7 to array controller B port 2. In this configuration, a single controller port can access all eight LUNs in the event of a path failure on the other three ports.

If you do install the optional Large LUN utility in your cluster, then you must follow these guidelines:

- Do not assign unit offsets to any connections.
- Use unit identifiers D0 through D63 for port 1 connections and D100 through D163 for port 2 connections.
- Distribute the LUNs evenly across all four array controller ports.

SCSI Cabling Examples

SCSI Bus Addressing

The two array controllers in each MA8000/EMA12000 Storage Subsystem controller enclosure receive I/O data from the cluster nodes, process it, and distribute this data over single-ended UltraSCSI buses to as many as six disk enclosures. Each bus has 16 possible SCSI bus identifier lDs (0-15).

The following devices use a SCSI bus address ID and are classified as SCSI bus "nodes":

- Array controllers (A and B)
- EMUs in the controller enclosure
- Physical disk drives in the disk enclosures

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Every node on a SCSI bus must have a unique SCSI bus ID.

Table 2-2 shows the SCSI bus address ID assignments for the MA8000/EMA12000 Storage Subsystem.

Table 2-2
SCSI bus address ID assignments for the MA8000/EMA12000 Storage Subsystem

SCSI Bus ID	SCSI Bus Node
0 - 5	Physical drives in disk enclosure
6	Array controller B
7	Array controller A
8, 9	EMUs in the controller enclosure
10 - 15	Physical drives in disk enclosure

Each disk enclosure has two internal SCSI buses, with each bus controlling half of the total available disk drive slots in the enclosure. The single-bus I/O module places all physical disk drives in the enclosure on a single bus of 12 devices. The dual-bus I/O module maintains two internal buses with seven physical disk drive slots on each bus.

For more detailed information about SCSI bus addressing for the MA8000/EMA12000 Storage Subsystem, refer to the Compaq documentation provided with the storage subsystem.

UltraSCSI Cables

Compaq recommends using the shortest cable length possible to connect disk enclosures to the controller enclosure. The maximum supported cable length is 2 meters (6.6 ft). Refer to the documentation provided with your storage subsystem for further information.

Using I/O Modules in the Controller Enclosure

As Figure 2-1 shows, both array controllers (A and B) connect to six I/O modules in the controller enclosure. UltraSCSI cables are installed between these I/O modules in the controller enclosure and one I/O module in each disk enclosure.

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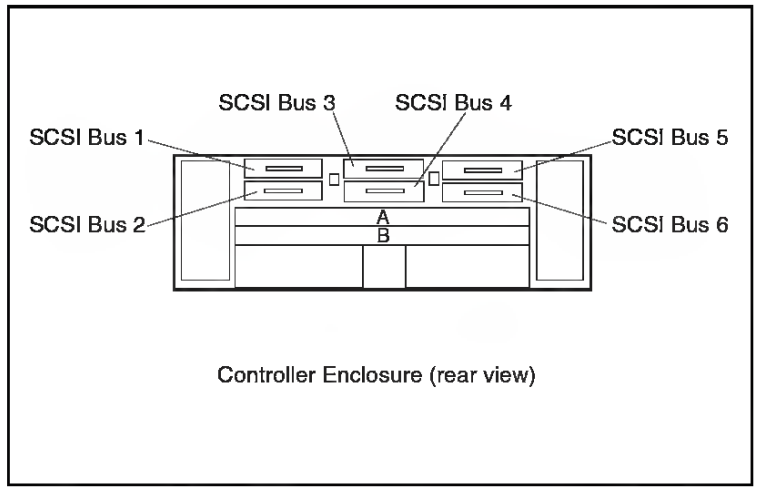

Figure 2-1. SCSI bus numbers for I/O modules in the controller enclosure

Using Dual-Bus I/O Modules in the Disk Enclosures

Figure 2-2 shows UltraSCSI cables installed between a controller enclosure and three disk enclosures. When three or fewer disk enclosures are present in a storage subsystem, use one dual-bus I/O module in each disk enclosure to support up to 14 disk drives in each disk enclosure. Using single-bus I/O modules limits you to 12 disk drives per disk enclosure.

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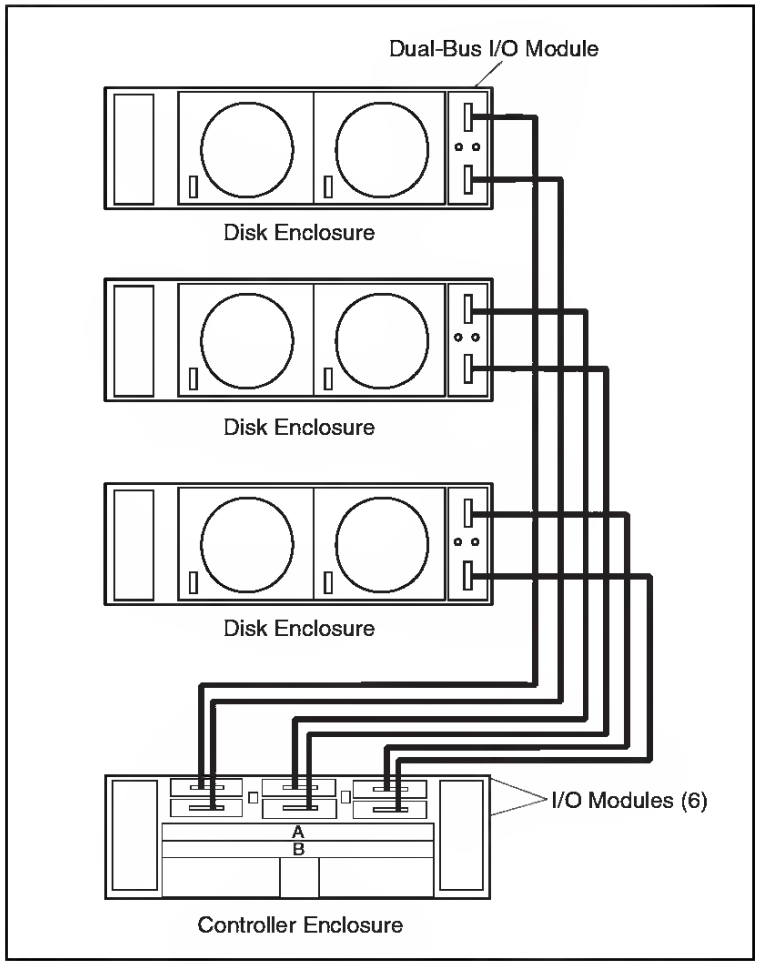

Figure 2-2. UltraSCSI cabling between a controller enclosure and three disk enclosures

Using Single-Bus I/O Modules in the Disk Enclosures

Figure 2-3 shows UltraSCSI cables installed between a controller enclosure and six disk enclosures. When four or more disk enclosures are present in a storage subsystem, use one single-bus I/O module in each disk enclosure.

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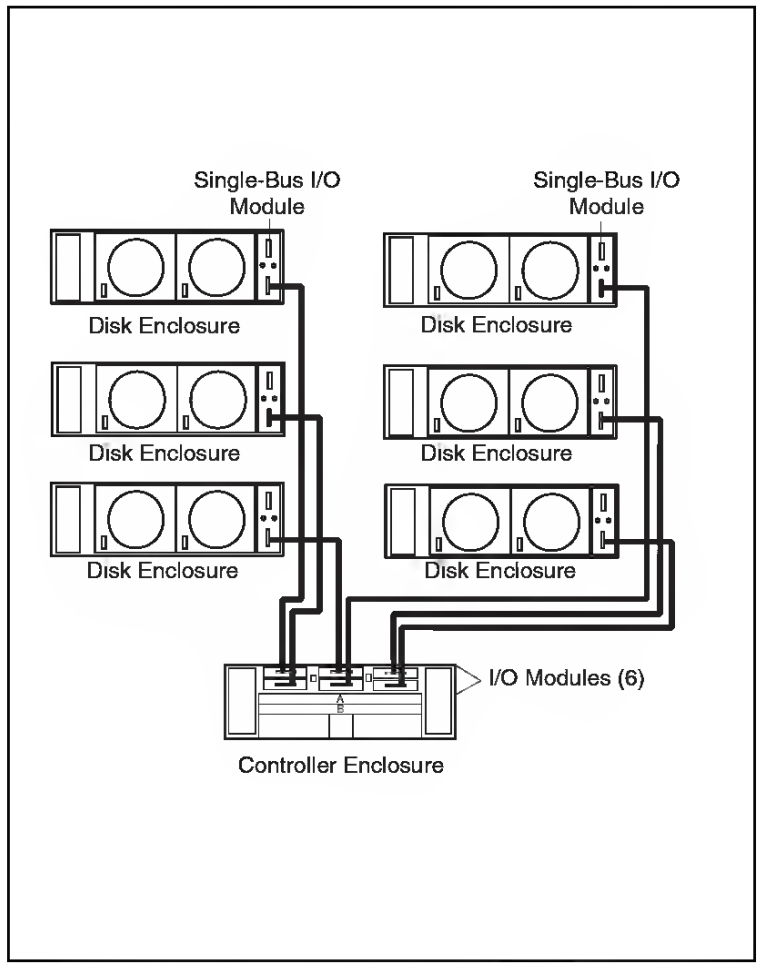

Figure 2-3. UltraSCSI cabling between a controller enclosure and six disk enclosures

Connecting EMUs Between MA8000/EMA12000 Storage Subsystems

For information about connecting the EMUs between enclosures in an MA8000/EMA12000 Storage Subsystem and between different subsystems, refer to the Compaq documentation provided with the storage subsystem.

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I/O Path Configurations for Redundant Fibre Channel Fabrics

Overview of Fibre Channel Fabric SAN Topology

Fibre Channel standards define a multi-layered architecture for moving data across the storage area network (SAN). This layered architecture can be implemented using the Fibre Channel Fabric or the Fibre Channel Arbitrated Loop (FC-AL) topology. The PDC/O5000 supports both topologies.

A redundant Fibre Channel Fabric is two to four Fibre Channel SAN Switches installed between host adapters in a PDC/O5000's cluster nodes and the array controllers in the shared storage subsystems. Fibre Channel SAN Switches provide full 100 MBps bandwidth per switch port. Whereas the introduction of new devices to FC-AL Storage Hubs further divides their shared bandwidth, adding new devices to Fibre Channel SAN Switches increases the aggregate bandwidth.

Redundant Fibre Channel Fabrics

A redundant Fibre Channel Fabric consists of the PDC/O5000 cluster hardware used to connect host adapters to a particular set of shared storage devices using Fibre Channel SAN Switches. Each redundant Fibre Channel Fabric consists of the following hardware:

- From two to four host adapters in each node
- From two to four Fibre Channel SAN Switches
- MA8000/EMA12000 Storage Subsystems, each containing two dual-port HSG80 Array Controllers
- Fibre Channel cables used to connect the host adapters to the Fibre Channel SAN Switches and the Fibre Channel SAN Switches to the array controllers
- GBIC-SW modules installed in host adapters, Fibre Channel SAN Switches, and array controllers

IMPORTANT: For detailed information about cascading two Fibre Channel SAN Switches, refer to the latest Compaq StorageWorks documentation. This guide does not document cascaded configurations for the Fibre Channel SAN Switch.

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A redundant Fibre Channel Fabric consists of from two to four individual fabrics. The number of fabrics present is determined by the number of host adapters installed in the redundant Fibre Channel Fabric: two host adapters create two fabrics and four host adapters create four fabrics.

Figure 2-4 shows a two-node PDC/O5000 with a redundant Fibre Channel Fabric that contains four fabrics, one for each host adapter.

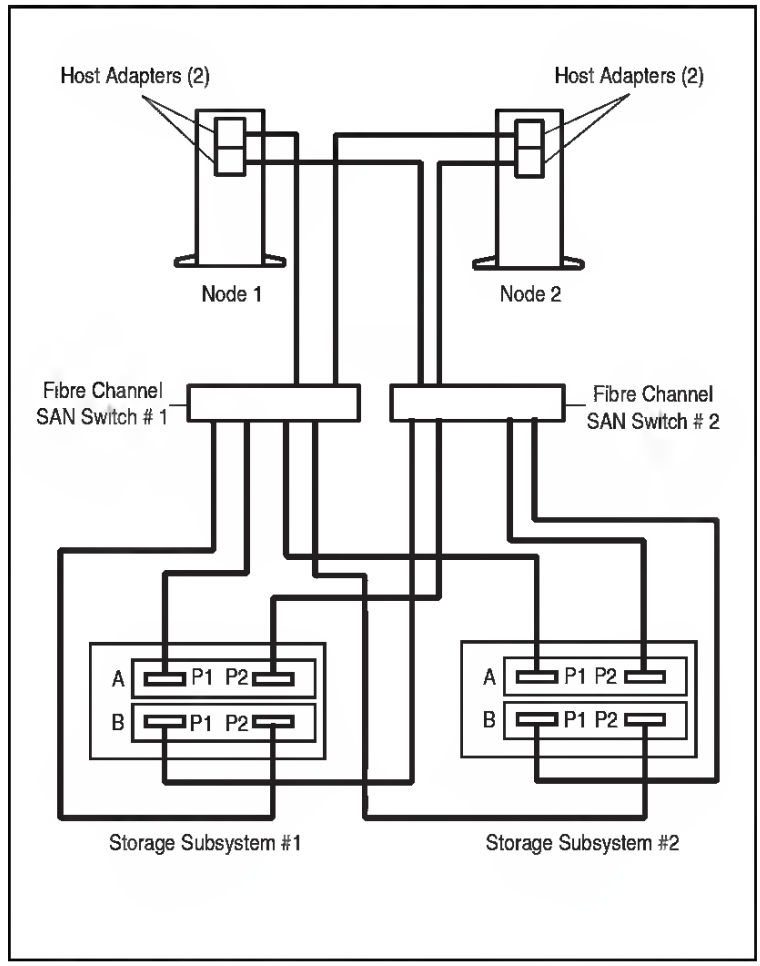

Figure 2-4. Two-node PDC/O5000 with a four-fabric redundant Fibre Channel Fabric

Used in conjunction with the I/O path failover capabilities of Compaq Secure Path software, this redundant Fibre Channel Fabric configuration gives cluster resources increased availability and fault tolerance.

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Multiple Redundant Fibre Channel Fabrics

The PDC/O5000 supports the use of multiple redundant Fibre Channel Fabrics within the same cluster. You would install additional redundant Fibre Channel Fabrics in a PDC/O5000 to:

- Increase the amount of shared storage space available to the cluster's nodes. Each redundant Fibre Channel Fabric can connect to a limited number of MA8000/EMA12000 Storage Subsystems. This limit is imposed by the number of ports available on the Fibre Channel SAN Switches used. The storage subsystems are available only to the host adapters connected to that redundant Fibre Channel Fabric.
- Increase the cluster's I/O performance.

Adding a second redundant Fibre Channel Fabric to the cluster involves duplicating the hardware components used in the first redundant Fibre Channel Fabric.

The maximum number of redundant Fibre Channel Fabrics you can install in a PDC/O5000 is restricted by the number of host adapters your Compaq servers support. Refer to the Compaq server documentation for this information.

Figure 2-5 shows a two-node PDC/O5000 with two redundant Fibre Channel Fabrics. In this example, each redundant Fibre Channel Fabric has its own pair of host adapters in each node, a pair of Fibre Channel SAN Switches, and two MA8000/EMA12000 Storage Subsystems. In Figure 2-5, the hardware components that constitute the second redundant Fibre Channel Fabric are shaded.

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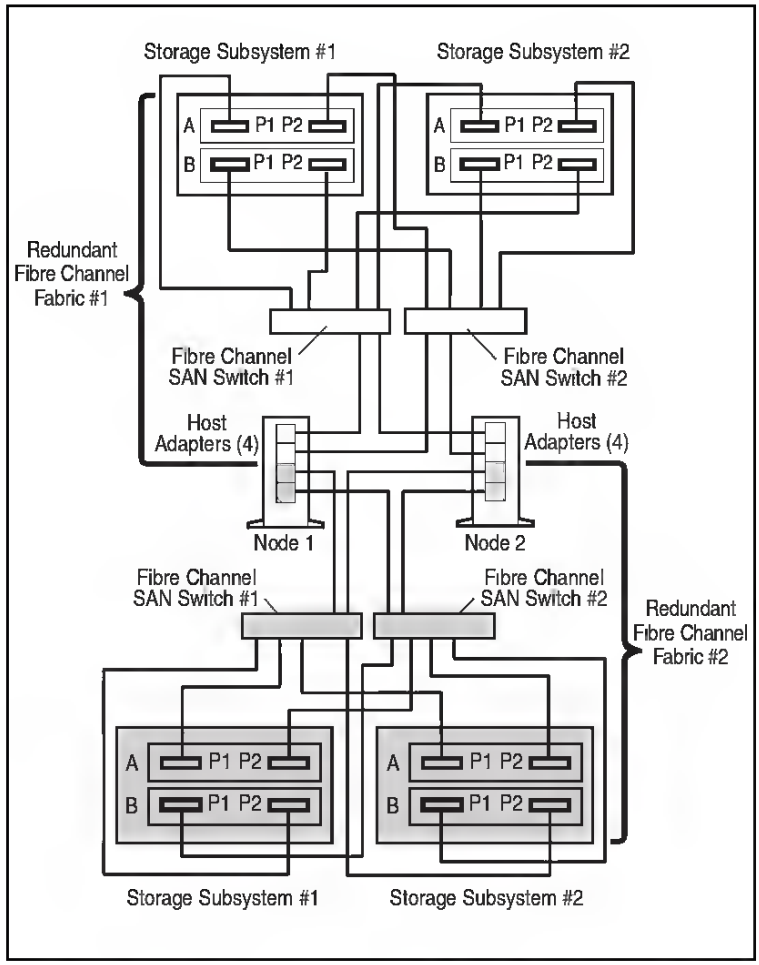

Figure 2-5. Two-node PDC/O5000 with two redundant Fibre Channel Fabrics

Maximum Distances Between Nodes and Shared Storage Subsystem Components

By using standard short-wave Fibre Channel cables with Gigabit Interface Converter-Shortwave (GBIC-SW) modules, the following maximum distances apply:

- Each MA8000/EMA12000 Storage Subsystem's controller enclosure can be placed up to 500 meters from the Fibre Channel SAN Switches.
- Each Fibre Channel SAN Switch can be placed up to 500 meters from the host adapters in the cluster nodes.

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Figure 2-6 illustrates these maximum cable distances for a redundant Fibre Channel Fabric.

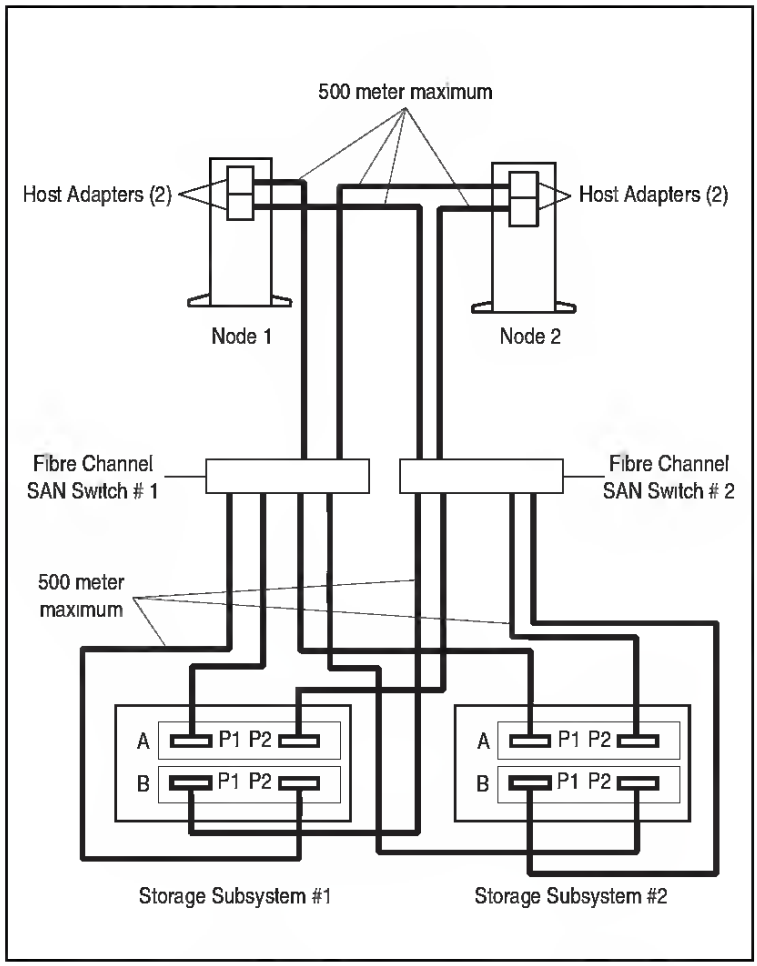

Figure 2-6. Maximum distances between PDC/O5000 cluster nodes and shared storage subsystem components in a redundant Fibre Channel Fabric

I/O Data Paths in a Redundant Fibre Channel Fabric

Within a redundant Fibre Channel Fabric, an I/O path connection exists between each host adapter and all four array controller ports in each storage subsystem.

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Host Adapter-to-Fibre Channel SAN Switch I/O Data Paths

Figure 2-7 highlights the I/O data paths that run between the host adapters and the Fibre Channel SAN Switches. Each host adapter has its own I/O data path.

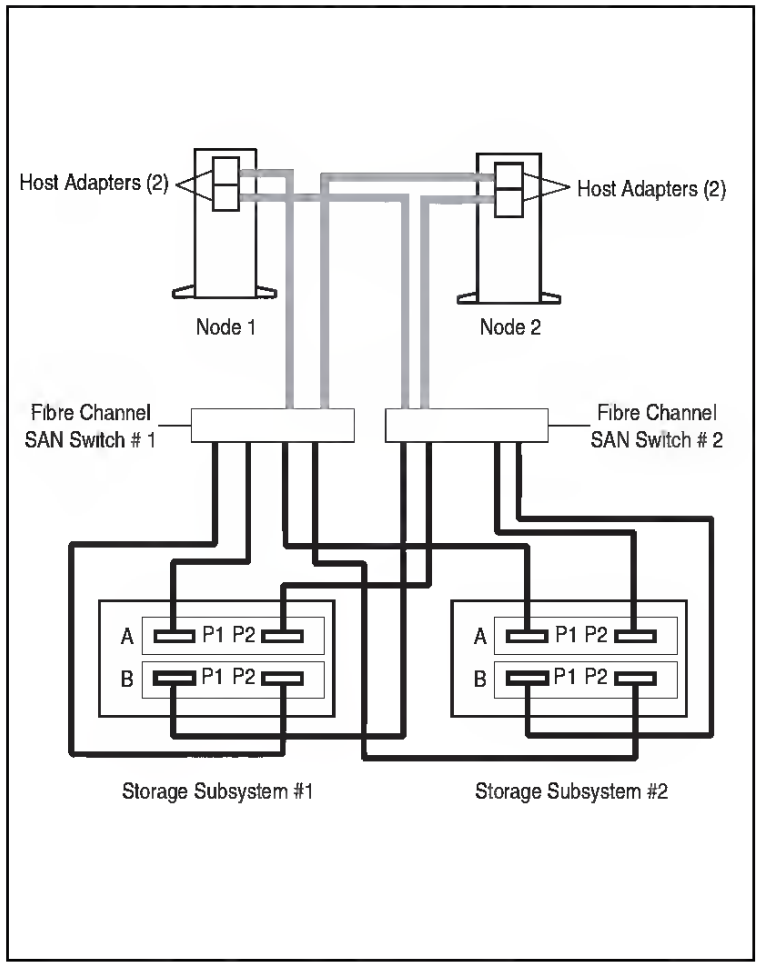

Figure 2-7. Host adapter-to-Fibre Channel SAN Switch I/O data paths

Secure Path monitors the status of the components along each active I/O path. If Secure Path detects the failure of a host adapter, Fibre Channel cable, or Fibre Channel SAN Switch along an active path, it automatically transfers all I/O activity on that path to the defined backup path.

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Fibre Channel SAN Switch-to-Array Controller I/O Data Paths

Figure 2-8 highlights the I/O data paths that run between the Fibre Channel SAN Switches and the two dual-port array controllers in each MA8000/EMA12000 Storage Subsystem. There is one I/O connection path to and from each array controller port.

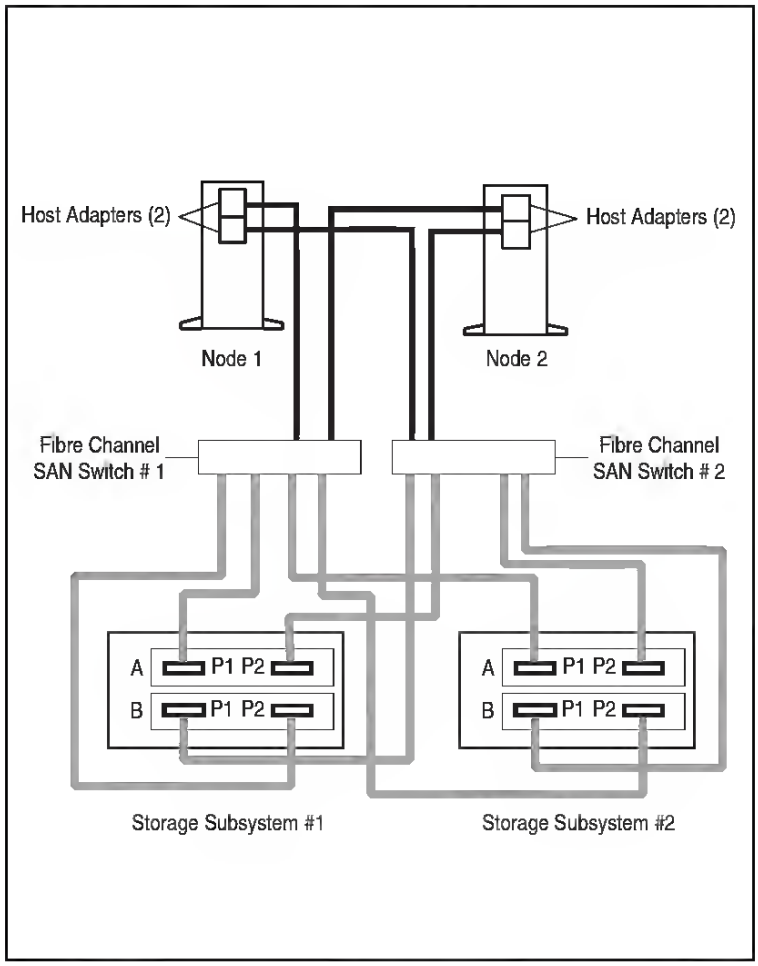

Figure 2-8. Fibre Channel SAN Switch-to-array controller I/O data paths

If any component along an active path fails, Secure Path detects the failure and automatically transfers all I/O activity to the components on the defined backup path.

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I/O Path Definitions for Redundant Fibre Channel Fabrics

In a redundant Fibre Channel Fabric, devices are accessed by the operating system using conventional SCSI addressing terminology. An I/O path consists of the complete physical interconnections from a given host (node) to a specific RAID storageset in a shared storage subsystem. Each path is identified by a unique 4-bit value that contains the port number (host adapter), bus number, and the unit name's target ID and LUN. Each unit name's target ID and LUN values use the format "D*xxyy*," where '*xx*' is the target number (0-15) and '*yy*' is the LUN (0-7). A target number of 0 is always dropped from the unit number designation (for example, the unit number D0 is understood to be LUN0 on target 0). A host (node) uses the unit name to specify the source or target for every I/O request it sends to an array controller. The unit name can identify a single physical disk drive unit or a storageset that contains several disk drives.

The port number (HBA) is assigned by the Windows operating system. Except for the LUN, the rest of the SCSI address is created within the host adapter miniport driver and is determined by the actual connections between Fibre Channel SAN Switch ports and array controller ports. Controller ports connected to lower-numbered Fibre Channel SAN Switch ports are assigned lower SCSI bus and target ID values than those connected to higher-numbered switch ports. The LUN number is derived from the unit number that has been assigned to the storageset using the StorageWorks Command Console (SWCC) or Command Line Interface (CLI) commands.

Each storageset created in a MA8000/EMA12000 Storage Subsystem must have a unique unit name. Since these storage subsystems present an identical address space from both of their two array controllers, the only bit of address information that will be different across the I/O paths from a given node to a specific storageset is the port (HBA) number.

While cluster nodes use the unit number (D*xxyy*) to identify and access a storageset or a single disk drive unit in the shared storage subsystems, the array controllers use a Port-Target-LUN (PTL) address to identify and access these resources in their storage subsystem. For the MA8000/EMA12000 Storage Subsystem, the PTL address contains the following information:

- The SCSI port number (1-6) identifies the disk enclosure in which the target physical disk drive is located.
- The target ID number (0-5 and 8-15) of the device identifies the physical disk drive.
- The LUN of the device (For disk devices, the LUN is always 0.)

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I/O Path Configuration Examples for Redundant Fibre Channel Fabrics

Every I/O path connection between host adapters and array controller ports is active at the same time. An active port does not become inactive unless it fails, whereupon all I/O activity on the failed path is automatically switched over to the pre-defined backup I/O path.

Dual Redundancy Configuration Example

In a redundant Fibre Channel Fabric, a dual redundancy configuration is the minimum allowable configuration that provides redundancy along the I/O paths. This configuration provides two of each component along the I/O paths. These include at least two nodes, two host adapters in each node, and two Fibre Channel SAN Switches.

Figure 2-9 shows the correct method for cabling the I/O path components in a dual redundancy configuration. In this example, both Fibre Channel SAN Switches connect to port 1 on one array controller and to port 2 on the other array controller in each MA8000/EMA12000 Storage Subsystem. If one Fibre Channel SAN Switch fails, the other switch still has access to port 1 on one array controller and port 2 on the other array controller in each storage subsystem. This ensures that the host adapters can still access the full range of LUNs.

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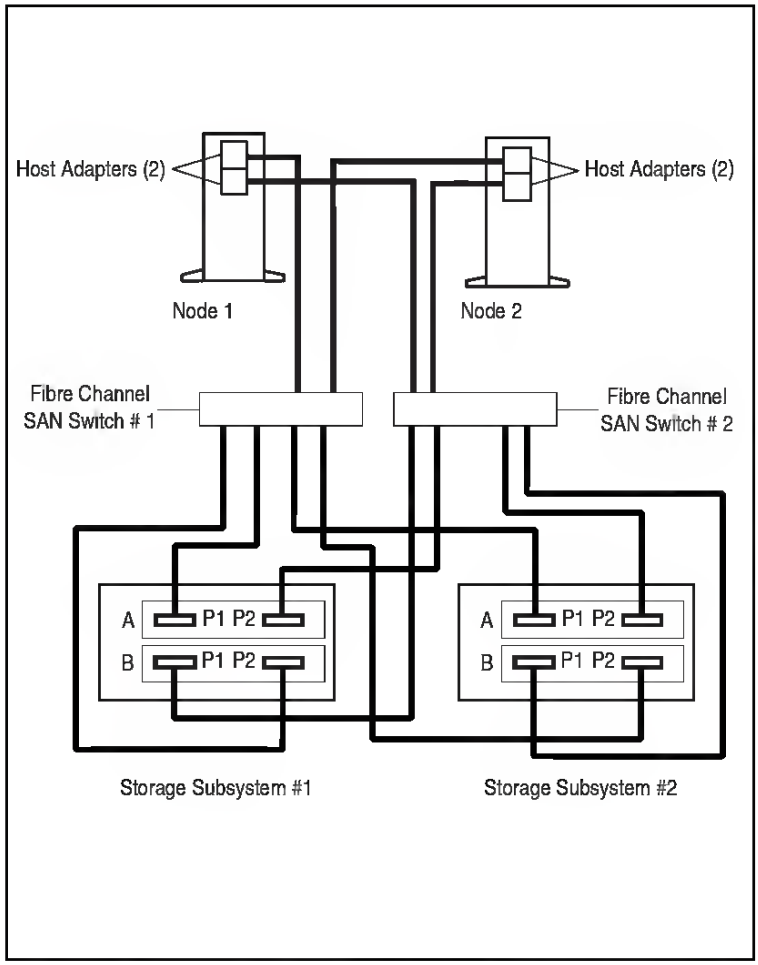

Figure 2-9. Dual redundancy configuration for a redundant Fibre Channel Fabric

Quad Redundancy Configuration Example

In a redundant Fibre Channel Fabric, a quad redundancy configuration provides four host adapters in each of at least four nodes and four Fibre Channel SAN Switches.

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Figure 2-10 shows an acceptable method for cabling the I/O path components in a quad redundancy configuration. In this example, the following connections are made:

- Each of four host adapters in each node connects to the same-numbered Fibre Channel SAN Switch (host adapter #1 to Fibre Channel SAN Switch #1, host adapter #2 to Fibre Channel SAN Switch #2, host adapter #3 to Fibre Channel SAN Switch #3, host adapter #4 to Fibre Channel SAN Switch #4).
- The two odd-numbered Fibre Channel SAN Switches connect to port 1 of the array controllers. Fibre Channel SAN Switch #1 connects to array controller A, port 1 in each storage subsystem. Fibre Channel SAN Switch #3 connects to array controller B, port 1 in each storage subsystem.
- The two even-numbered Fibre Channel SAN Switches connect to port 2 of the array controllers. Fibre Channel SAN Switch #2 connects to array controller A, port 2 in each storage subsystem. Fibre Channel SAN Switch #4 connects to array controller B, port 2 in each storage subsystem.

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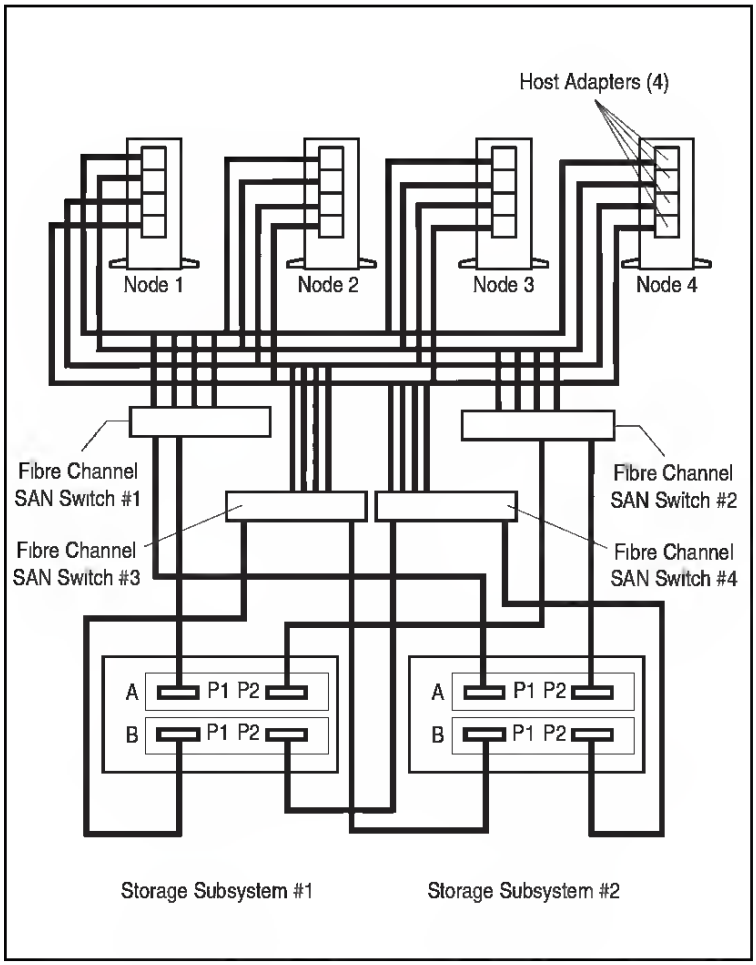

Figure 2-10. Quad redundancy configuration for a redundant Fibre Channel Fabric

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Summary of I/O Path Failure and Failover Scenarios for Redundant Fibre Channel Fabrics

Table 2-3 identifies possible I/O path failure events for both dual redundancy or quad redundancy configurations in a redundant Fibre Channel Fabric and the failover response implemented by Secure Path for each failure.

Table 2-3
I/O Path Failure and Failover Scenarios for Redundant Fibre Channel Fabrics

Description of Failure	Failover Response
A single port on an array controller fails.	The I/O path to the defined backup array controller port takes over all I/O activity.
One array controller in a storage subsystem fails.	The I/O paths to both ports on the other array controller take over all I/O activity.
The Fibre Channel cable connection between an array controller and its Fibre Channel SAN Switch is broken.	The I/O path to the defined backup array controller port takes over all I/O activity.
A Fibre Channel SAN Switch fails.	The I/O paths for another fabric take over all I/O activity.
The Fibre Channel cable connection between a host adapter and a Fibre Channel SAN Switch is broken.	The I/O path from the host adapter in the node that is connected to the defined backup array controller port takes over all I/O activity.
A host adapter fails.	The I/O path from the host adapter in the same node that is connected to the defined backup array controller port takes over all I/O activity.

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I/O Path Configurations for Redundant Fibre Channel Arbitrated Loops

Overview of FC-AL SAN Topology

Fibre Channel standards define a multi-layered architecture for moving data across the storage area network (SAN). This layered architecture can be implemented using the Fibre Channel Fabric or the Fibre Channel Arbitrated Loop (FC-AL) topology. The PDC/O5000 supports both topologies.

Storage Hubs are used to create redundant FC-ALs with a total 100 MBps bandwidth divided among all Storage Hub ports. The functional bandwidth available to any one device on a Storage Hub port is determined by the total population on the segment and the level of activity of devices on other ports. The more devices used, the less bandwidth that is available for each port.

Redundant Fibre Channel Arbitrated Loops

A redundant FC-AL consists of the PDC/O5000 cluster hardware used to connect host adapters to a particular set of shared storage devices using Storage Hubs. Each redundant FC-AL consists of the following hardware:

- From two to four host adapters in each node
- From two to four Storage Hubs
- MA8000/EMA12000 Storage Subsystems, each containing two dual-port HSG80 Array Controllers
- Fibre Channel cables used to connect the host adapters to the Storage Hubs and the Storage Hubs to the array controllers
- GBIC-SW modules installed in host adapters, Storage Hubs, and array controllers

A redundant FC-AL consists of from two to four individual loops. The number of loops present is determined by the number of host adapters installed in the redundant FC-AL: two host adapters create two loops and four host adapters create four loops.

Figure 2-11 shows a two-node PDC/O5000 with a redundant FC-AL that contains four loops, one for each host adapter.

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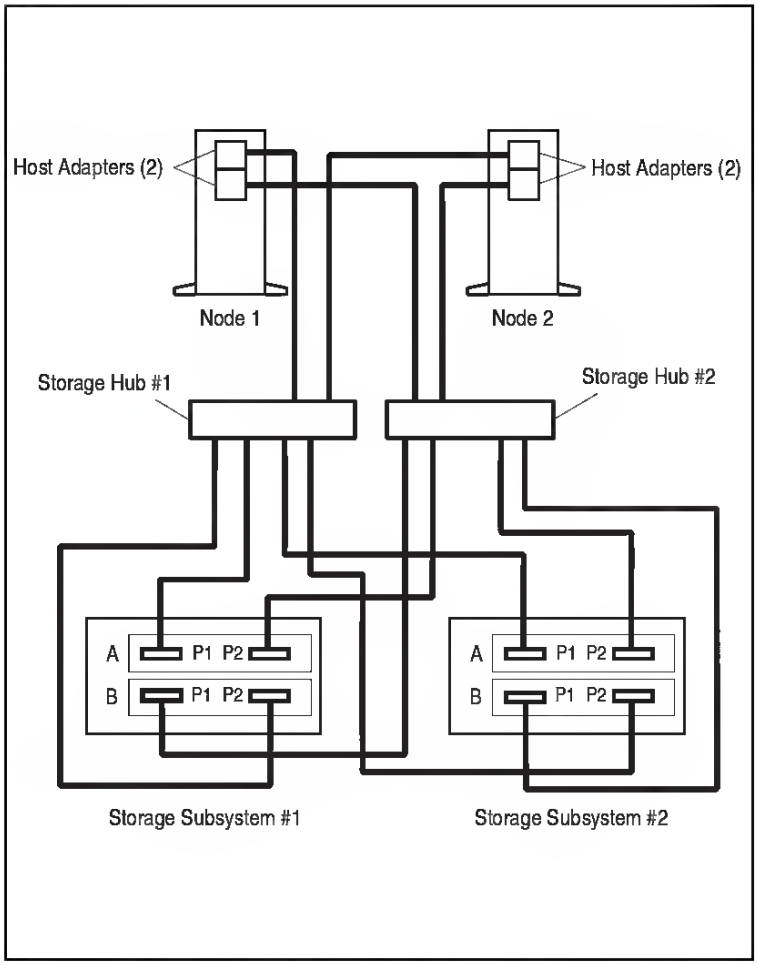

Figure 2-11. Two-node PDC/O5000 with a four-loop redundant Fibre Channel Arbitrated Loop

Used in conjunction with the I/O path failover capabilities of the Secure Path software, this redundant FC-AL configuration gives cluster resources increased availability and fault tolerance.

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Multiple Redundant Fibre Channel Arbitrated Loops

The PDC/O5000 supports the use of multiple redundant FC-ALs within the same cluster. You would install additional redundant FC-ALs in a PDC/O5000 to:

- Increase the amount of shared storage space available to the cluster's nodes. Each redundant FC-AL can connect to a limited number of MA8000/EMA12000 Storage Subsystems. This limit is imposed by the number of ports available on the Storage Hubs used. The storage subsystems are available only to the host adapters connected to that redundant FC-AL.
- Increase the cluster's I/O performance.

Adding a second redundant FC-AL to the cluster involves duplicating the hardware components used in the first redundant FC-AL.

The maximum number of redundant FC-ALs you can install in a PDC/O5000 is restricted by the number of host adapters your Compaq servers support. Refer to the Compaq server documentation for this information.

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Figure 2-12 shows a two-node PDC/O5000 that contains two redundant FC-ALs. In this example, each redundant FC-AL has its own pair of host adapters in each node, a pair of Storage Hubs, and two MA8000/EMA12000 Storage Subsystems. In Figure 2-12, the hardware components that constitute the second redundant FC-AL are shaded.

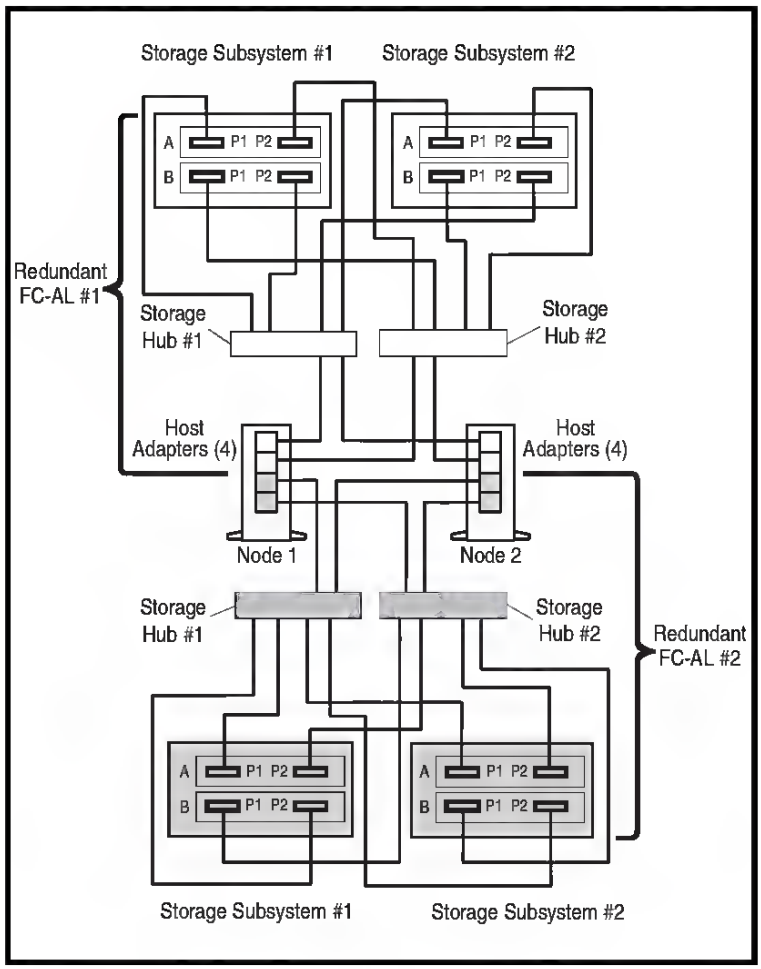

Figure 2-12. Two-node PDC/O5000 with two redundant Fibre Channel Arbitrated Loops

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Maximum Distances Between Nodes and Shared Storage Subsystem Components

By using standard short-wave Fibre Channel cables with Gigabit Interface Converter-Shortwave (GBIC-SW) modules, the following maximum distances apply:

- Each MA8000/EMA12000 Storage Subsystem's controller enclosure can be placed up to 500 meters from the Storage Hubs.
- Each Storage Hub can be placed up to 500 meters from the host adapters in the cluster nodes.

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Figure 2-13 illustrates these maximum cable distances for a redundant FC-AL.

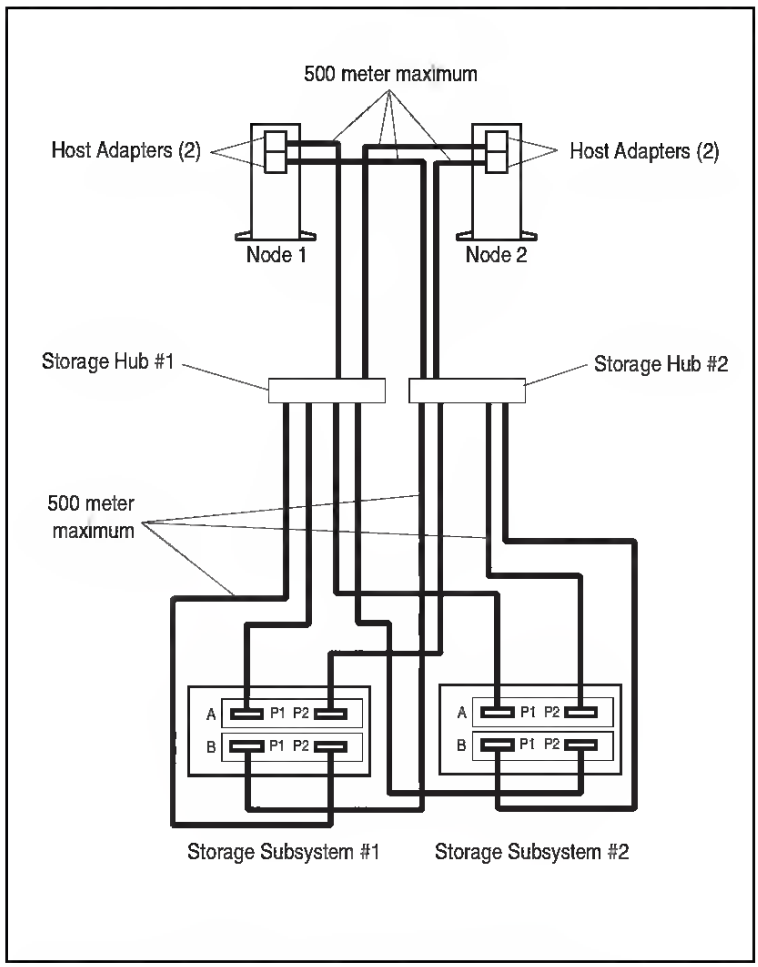

Figure 2-13. Maximum distances between PDC/O5000 cluster nodes and shared storage subsystem components in a redundant FC-AL

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I/O Data Paths in a Redundant FC-AL

Within a redundant FC-AL, an I/O path connection exists between each host adapter and all four array controller ports in each storage subsystem.

Host Adapter-to-Storage Hub I/O Data Paths

Figure 2-14 highlights the I/O data paths that run between the host adapters and the Storage Hubs. Each host adapter has its own I/O data path.

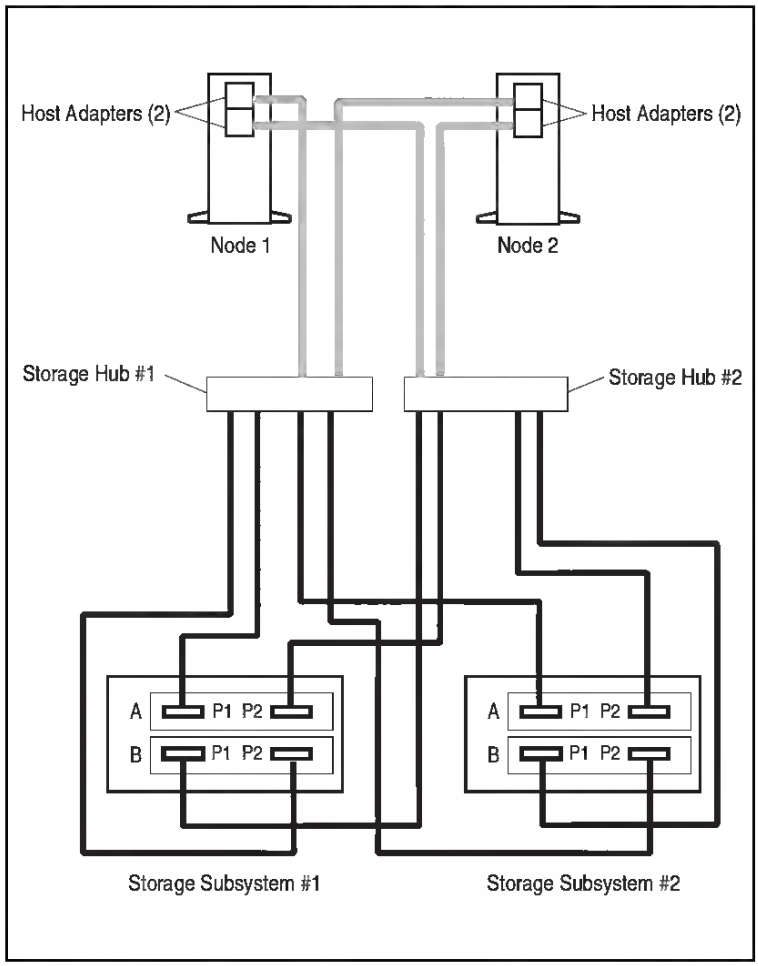

Figure 2-14. Host adapter-to-Storage Hub I/O data paths

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Secure Path monitors the status of the components along each active path. If Secure Path detects the failure of a host adapter, Fibre Channel cable, or Storage Hub along an active path, it automatically transfers all I/O activity on that path to the defined backup path.

Storage Hub-to-Array Controller I/O Data Paths

Figure 2-15 highlights the I/O data paths that run between the Storage Hubs and the two dual-port HSG80 Array Controllers in each MA8000/EMA12000 Storage Subsystem. There is one I/O connection path to and from each array controller port.

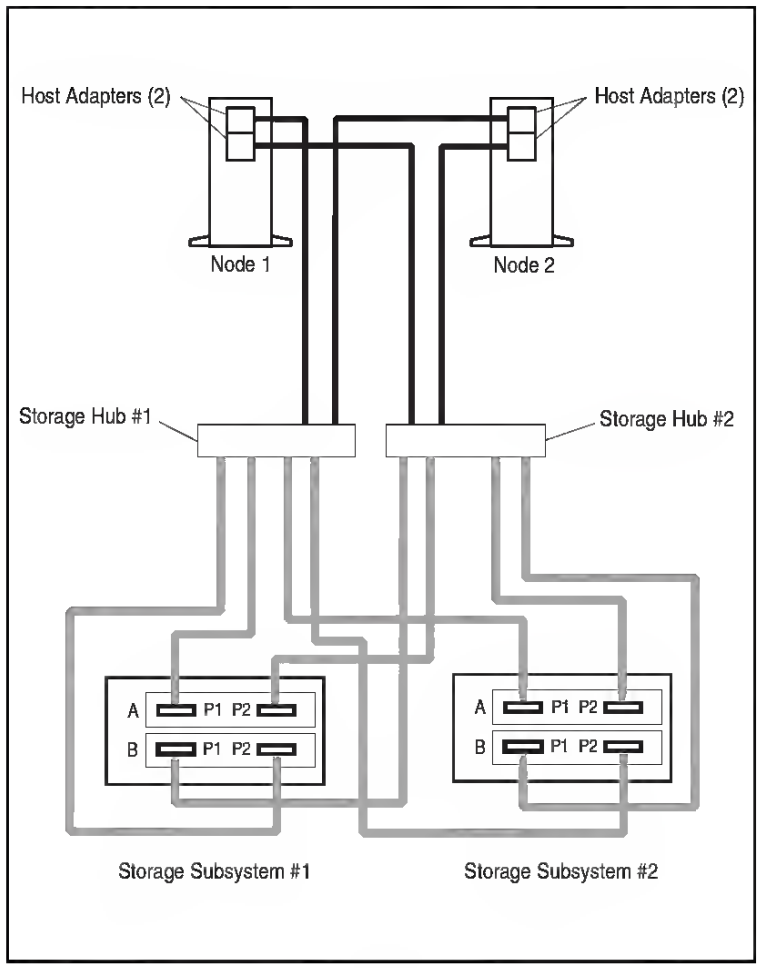

Figure 2-15. Storage Hub-to-array controller I/O data paths

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If any component along an active path fails, Secure Path detects the failure and automatically transfers all I/O activity to the defined backup path.

I/O Path Definitions for Redundant FC-ALs

In a redundant FC-AL, devices are accessed by the operating system using conventional SCSI addressing terminology. An I/O path consists of the complete physical interconnections from a given host (node) to a specific RAID storageset in a shared storage subsystem. Each path is identified by a unique 4-bit value that contains the port number (host adapter), bus number, and the unit name's target ID and LUN. Each unit name's target ID and LUN values use the format "D*xxyy*," where '*xx*' is the target number (0-15) and '*yy*' is the LUN (0-7). A target number of 0 is always dropped from the unit number designation (for example, the unit number D0 is understood to be LUN0 on target 0). A host (node) uses the unit name to specify the source or target for every I/O request it sends to an array controller. The unit name can identify a single physical disk drive unit or a storageset that contains several disk drives.

The port number (HBA) is assigned by the Windows 2000 Advanced Server operating system. Except for the LUN, the rest of the SCSI address is created within the host adapter miniport driver and is derived from the Arbitrated Loop Physical Address (ALPA) assigned to each of the four array controller ports in a shared storage subsystem. The miniport driver uses a fixed mapping scheme to translate ALPA assignments to SCSI bus and target ID values. The LUN number is derived from the unit number that has been assigned to the storageset using the StorageWorks Command Console (SWCC) or Command Line Interface (CLI) commands. Each node must also have a unique ALPA.

Each storageset created in a MA8000/EMA12000 Storage Subsystem must have a unique unit name. Since these storage subsystems present an identical address space from both of their two array controllers, the only bit of address information that will be different across the I/O paths from a given node to a specific storageset is the port (HBA) number.

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While cluster nodes use the unit number (D*xxyy*) to identify and access a storageset or a single disk drive unit in the shared storage subsystems, the array controllers use a Port-Target-LUN (PTL) address to identify and access these resources in their storage subsystem. For the MA8000/EMA12000 Storage Subsystem, the PTL address contains the following information:

- The SCSI port number (1-6) identifies the disk enclosure in which the target physical disk drive is located.
- The target ID number (0-5 and 8-15) of the device identifies the physical disk drive.
- The LUN of the device (for disk devices, the LUN is always 0).

I/O Path Configuration Examples for Redundant FC-ALs

Every I/O path connection between host adapters and array controller ports is active at the same time. An active port does not become inactive unless it fails, whereupon all I/O activity on the failed path is automatically switched over to the pre-defined backup I/O path.

Dual Redundancy Configuration Example

In a redundant FC-AL, a dual redundancy configuration is the minimum allowable configuration that provides redundancy along the I/O paths. This configuration provides two of each component along the I/O paths. These include at least two nodes, two host adapters in each node, and two Storage Hubs.

Figure 2-16 shows the correct method for cabling the I/O path components in a dual redundancy configuration. In this example, both Storage Hubs connect to port 1 on one array controller and to port 2 on the other array controller in each MA8000/EMA12000 Storage Subsystem. If one Storage Hub fails, the other Storage Hub still has access to port 1 on one array controller and port 2 on the other array controller in each storage subsystem. This ensures that the host adapters can still access the full range of LUNs.

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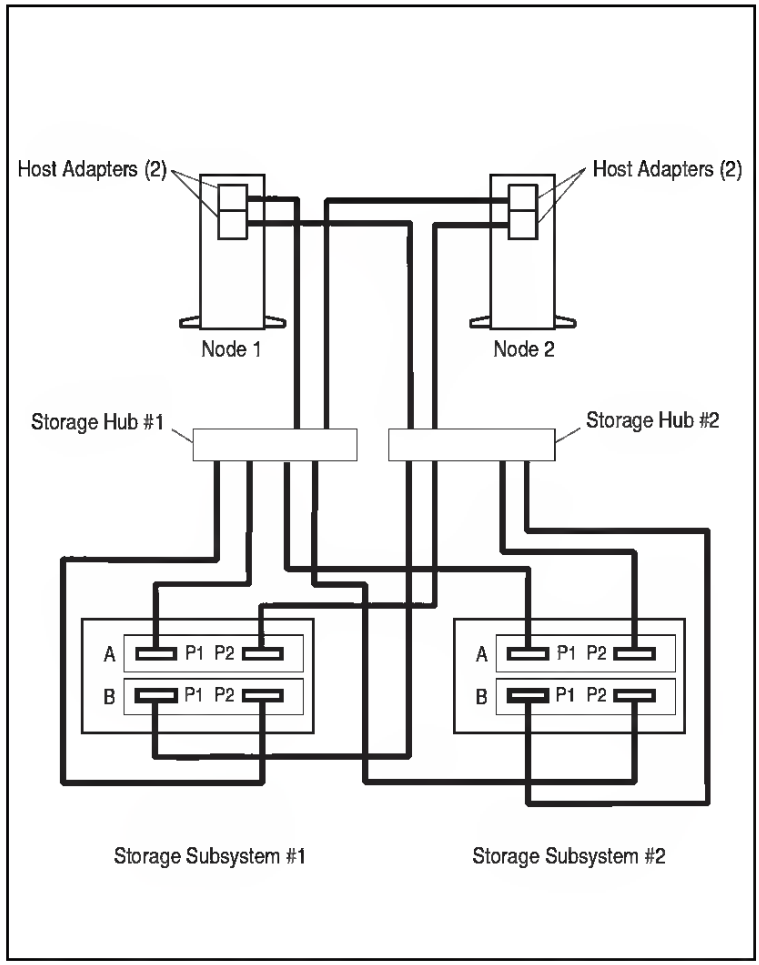

Figure 2-16. Dual redundancy configuration for a redundant FC-AL

Quad Redundancy Configuration Example

In a redundant FC-AL, a quad redundancy configuration provides four host adapters in each of at least four nodes and four Storage Hubs.

Figure 2-17 shows an acceptable method for cabling the I/O path components in a quad redundancy configuration. In this example, the following connections are made:

- Each of four host adapters in each node connects to the same-numbered Storage Hub (host adapter #1 to Storage Hub #1, host adapter #2 to Storage Hub #2, host adapter #3 to Storage Hub #3, host adapter #4 to Storage Hub #4).

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- The two odd-numbered Storage Hubs connect to port 1 of the array controllers. Storage Hub #1 connects to array controller A, port 1 in each storage subsystem. Storage Hub #3 connects to array controller B, port 1 in each storage subsystem.
- The two even-numbered Storage Hubs connect to port 2 of the array controllers. Storage Hub #2 connects to array controller A, port 2 in each storage subsystem. Storage Hub #4 connects to array controller B, port 2 in each storage subsystem.

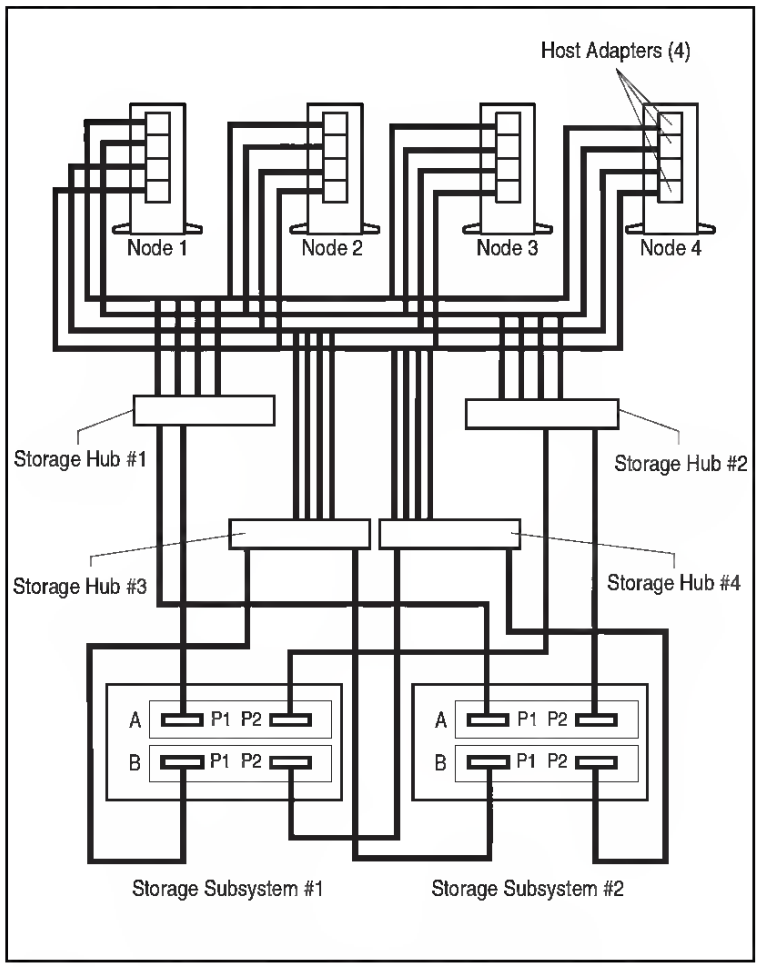

Figure 2-17. Quad redundancy configuration for a redundant FC-AL

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Summary of I/O Path Failure and Failover Scenarios for Redundant FC-ALs

Table 2-4 identifies possible I/O path failure events for both dual redundancy and quad configurations for a redundant FC-AL and the failover response implemented by Secure Path for each failure.

Table 2-4
I/O Path Failure and Failover Scenarios for Redundant FC-ALs

Description of Failure	Failover Response
A single port on an array controller fails.	The I/O path to the defined backup array controller port takes over all I/O activity.
One array controller in a storage subsystem fails.	The I/O paths to both ports on the other array controller take over all I/O activity.
The Fibre Channel cable connection between an array controller and its Storage Hub is broken.	The I/O path to the defined backup array controller port takes over all I/O activity.
A Storage Hub fails.	The I/O paths for another loop take over all I/O activity.
The Fibre Channel cable connection between a host adapter and a Storage Hub is broken.	The I/O path from the host adapter in the node that is connected to the defined backup array controller port takes over all I/O activity.
A host adapter fails.	The I/O path from the host adapter in the same node that is connected to the defined backup array controller port takes over all I/O activity.

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Cluster Interconnect Requirements

The cluster interconnect is the data path over which all of the nodes in a PDC/O5000 cluster communicate. The nodes use the cluster interconnect data path to:

- Communicate individual resource and overall cluster status.
- Send and receive heartbeat signals.
- Coordinate database locks through the Oracle Integrated Distributed Lock Manager.

NOTE: Several terms for *cluster interconnect* are used throughout the industry. Others are: private LAN, private interconnect, system area network (SAN), and private network. Throughout this guide, the term *cluster interconnect* is used.

Compaq Parallel Database Clusters like the PDC/O5000 that use Oracle8*i* Parallel Server support an Ethernet cluster interconnect.

In a PDC/O5000, the Ethernet cluster interconnect must be redundant. A redundant cluster interconnect uses redundant hardware to provide fault tolerance along the entire cluster interconnect path.

Ethernet Cluster Interconnect

IMPORTANT: The cluster management software for the Ethernet cluster interconnect requires the use of TCP/IP. When configuring the Ethernet cluster interconnect, be sure to enable TCP/IP.

NOTE: Refer to the technical white paper *Supported Ethernet Interconnects for Compaq Parallel Database Clusters Using Oracle Parallel Server* (ECG062/0299) for detailed information about configuring redundant Ethernet cluster interconnects. This document is available at

www.compaq.com/support/techpubs/whitepapers

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Ethernet Cluster Interconnect Components

The following components are used in a redundant Ethernet cluster interconnect:

- Two Ethernet adapters in each cluster node
- Ethernet cables and switches or hubs
  - For two-node PDC/O5000 clusters, you can use two 100-Mbit/second Ethernet switches or hubs with cables to connect the servers.
  - For PDC/O5000 clusters with three or more nodes, you use two 100-Mbit/second Ethernet switches connected by Ethernet cables to a separate Ethernet adapter in each server.

NOTE: In a redundant Ethernet cluster configuration, one Ethernet crossover cable must be installed between the two Ethernet switches or hubs that are dedicated to the cluster interconnect.

Ethernet Cluster Interconnect Adapters

To implement the Ethernet cluster interconnect, each cluster node must be equipped with Ethernet adapters capable of 100-Mbit/second transfer rates. Some adapters may be capable of operating at both 10-Mbit/second and 100-Mbit/second; however, Ethernet adapters used for the cluster interconnect must run at 100-Mbit/second.

The Ethernet adapters must have passed Windows 2000 Advanced Server HCT certification.

For more information about installing an Ethernet cluster interconnect, see Chapter 5, "Installation and Configuration."

Ethernet Switch

IMPORTANT: The Ethernet switch or switches used with the Ethernet cluster interconnect must be dedicated to the cluster interconnect. They cannot be connected to the client network (LAN) or to servers that are not part of the PDC/O5000 cluster.

When an Ethernet cluster interconnect is used in a cluster with three or more nodes, a 100-Mbit/second Ethernet switch is required for the cluster interconnect path. The 100-Mbit/second Ethernet switch handles the higher network loads essential to the uninterrupted operation of the cluster. An Ethernet hub cannot be used.

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Ethernet Cluster Interconnect Diagrams

Figure 2-18 shows the redundant Ethernet cluster interconnect components used in a two-node PDC/O5000 cluster.

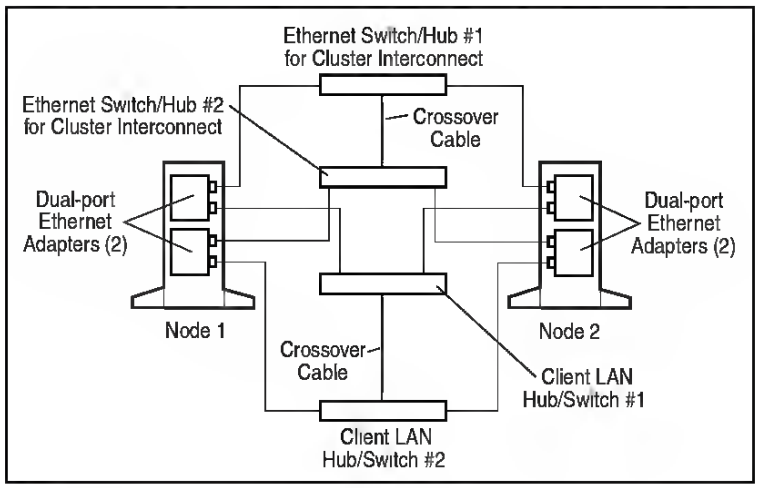

Figure 2-18. Redundant Ethernet cluster interconnect for a two-node PDC/O5000 cluster

These components include two dual-port Ethernet adapters in each cluster node. The top port on each adapter connects by Ethernet cable to one of two Ethernet switches or hubs provided for the cluster interconnect. The bottom port on each adapter connects by Ethernet cable to the client LAN for the cluster. A crossover cable is installed between the two Ethernet switches or hubs used in the Ethernet cluster interconnect.

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Local Area Network

NOTE: For the PDC/O5000, the client LAN and the cluster interconnect must be treated as separate networks. Do not use either network to handle the other network's traffic.

Every client/server application requires a local area network, or LAN, over which client machines and servers communicate. In the case of a cluster, the hardware components of the client LAN are no different than in a standalone server configuration.

The software components used by network clients should have the ability to detect node failures and automatically reconnect the client to another cluster node. For example, Net8, Oracle Call Interface (OCI) and Transaction Process Monitors can be used to address this issue.

NOTE: For complete information on how to ensure client auto-reconnect in an Oracle8*i* Parallel Server environment, contact your Oracle representative.

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Chapter 3

Cluster Software Components

Overview of the Cluster Software

The Compaq Parallel Database Cluster Model PDC/O5000 (referred to here as the PDC/O5000) combines software from several leading computer vendors. The integration of these components creates a stable cluster management environment in which the Oracle database can operate.

For the PDC/O5000, the cluster management software is a combination of Compaq operating system dependent modules (OSDs) and this Oracle software:

- Oracle8*i* Enterprise Edition with the Oracle8*i* Parallel Server Option

  NOTE: For information about currently-supported software revisions for the PDC/O5000, refer to the *Compaq Parallel Database Cluster Model PDC/O5000 Certification Matrix for Windows 2000* at

  www.compaq.com/solutions/enterprise/ha-pdc.html

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Microsoft Windows 2000 Advanced Server

This version of the PDC/O5000 supports Microsoft Windows 2000 Advanced Server with Service Pack 1 or later.

NOTE: The PDC/O5000 does not work in conjunction with Microsoft Cluster Server. Do not install Microsoft Cluster Server on any of the cluster nodes.

Compaq Software

Compaq offers an extensive set of features and optional tools to support effective configuration and management of the PDC/O5000:

- Compaq *SmartStart*™ and Support Software
- Compaq System Configuration Utility
- *Compaq Insight Manager*™
- Compaq Insight Manager XE
- Compaq Options *ROMPaq*™
- Compaq StorageWorks Command Console
- Compaq StorageWorks Secure Path for Windows 2000
- Compaq operating system dependent modules (OSDs)

Compaq SmartStart and Support Software

SmartStart, which is located on the SmartStart and Support Software CD, is the best way to configure Windows 2000 Advanced Server on a PDC/O5000 cluster. SmartStart uses an automated step-by-step process to configure the operating system and load the system software.

The Compaq SmartStart and Support Software CD also contains device drivers and utilities that enable you to take advantage of specific capabilities offered on Compaq products. These drivers are provided for use with Compaq hardware only.

The PDC/O5000 requires version 4.9 of the SmartStart and Support Software CD. For information about SmartStart, refer to the Compaq Server Setup and Management pack.

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Compaq System Configuration Utility

The SmartStart and Support Software CD also contains the Compaq System Configuration Utility. This utility is the primary means to configure hardware devices within your servers, such as I/O addresses, boot order of disk controllers, and so on.

For information about the System Configuration Utility, see the Compaq Server Setup and Management pack.

Compaq Insight Manager

Compaq Insight Manager, loaded from the Compaq Management CD, is a software utility used to collect information about the servers in the cluster. Compaq Insight Manager performs these functions:

- Monitors server fault conditions and status
- Forwards server alert fault conditions
- Remotely controls servers

The Integrated Management Log is used to collect and feed data to Compaq Insight Manager. This log is used with the Compaq Integrated Management Display (IMD), the optional Remote Insight controller, and SmartStart.

In Compaq servers, each hardware subsystem, such as non-shared disk storage, system memory, and system processor, has a robust set of management capabilities. Compaq Full Spectrum Fault Management notifies the end user of impending fault conditions.

For information about Compaq Insight Manager, refer to the documentation you received with your Compaq ProLiant server.

Compaq Insight Manager XE

Compaq Insight Manager XE is a Web-based management system. It can be used in conjunction with Compaq Insight Manager agents as well as its own Web-enabled agents. This browser-based utility provides increased flexibility and efficiency for the administrator.

Compaq Insight Manager XE is an optional CD available upon request from the Compaq System Management website at

www.compaq.com/sysmanage

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Compaq Options ROMPaq

The Compaq Options ROMPaq diskettes allow a user to upgrade the ROM Firmware images for Compaq System product options, such as array controllers, disk drives, and tape drives used for non-shared storage.

Compaq StorageWorks Command Console

The Compaq StorageWorks Command Console (SWCC) is a graphical user interface (GUI) used to create, configure, and manage MA8000/EMA12000 Storage Subsystem resources in a PDC/O5000 cluster, including RAID implementation, disk mirroring, and disk partitioning.

The SWCC provides a user-friendly method of executing the Command Line Interface (CLI) commands for the HSG80 Array Controllers. While the CLI window provides very detailed control over the storage subsystem, the SWCC replicates most of the CLI window functions in a graphic form and provides a user-friendly method of executing CLI commands.

For details about using SWCC, refer to the documentation provided with the HSG80 Array Controller.

Compaq StorageWorks Secure Path for Windows 2000

Compaq StorageWorks Secure Path for Windows 2000 (Secure Path) must be installed on each server (node) in the PDC/O5000. Secure Path monitors all I/O paths to the storagesets in the shared storage subsystems. If any component along an active I/O path fails, Secure Path detects this failure and automatically reroutes I/O activity through the defined backup path. Failovers are transparent and non-disruptive to applications.

Secure Path Manager is the client application used to manage multiple path StorageWorks RAID array configurations. Secure Path Manager displays a graphical presentation of the current multiple I/O path environment and indicates the location and state of all configured storage units on each path. To facilitate load balancing, Secure Path Manager provides the capability to move storagesets from their configured paths to other paths during normal cluster operation. Secure Path Manager can be run locally at the cluster nodes or remotely at a management station.

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You can also install the optional Compaq StorageWorks Large LUN utility with the Secure Path software. This utility allows cluster nodes to access up to 64 LUNs per target (array controller port).

Compaq Operating System Dependent Modules

Compaq supplies low-level services, called operating system dependent modules (OSDs), which are required by Oracle8*i* Parallel Server. The OSD layer monitors critical clustering hardware components, constantly relaying cluster state information to Oracle8*i* Parallel Server. Oracle8*i* Parallel Server monitors this information and takes pertinent action as needed.

For example, the OSD layer is responsible for monitoring the cluster interconnect of each node in the cluster. The OSD layer determines if one of the nodes is no longer responding to the cluster heartbeat. If the node still does not respond, the OSD layer determines it is unavailable. The OSD layer evicts the node from the cluster and informs Oracle8*i* Parallel Server. Oracle8*i* Parallel Server recovers the part of the database affected by that node, and reconfigures the cluster with the remaining nodes.

OSDs for Oracle8*i* Parallel Server

For a detailed description of how the OSD layer interacts with Oracle8*i* Parallel Server, refer to the *Oracle8i Parallel Server Setup and Configuration Guide* provided with the Oracle8*i* software.

The OSD software is found on the Compaq Parallel Database Cluster Clustering Software for Oracle8*i* on Microsoft Windows 2000 CD. This CD is included in the cluster kit for the PDC/O5000.

Oracle Software

The PDC/O5000 supports Oracle8*i* software. If you are using a release other than Oracle8*i* Release 8.1.7, confirm that the release has been certified for the PDC/O5000 on the Compaq website at

www.compaq.com/solutions/enterprise/ha-pdc.html

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Oracle8*i* Server Enterprise Edition

The Oracle8*i* Server Enterprise Edition provides the following:

- Oracle8*i* Server
- Oracle8*i* Parallel Server Option
- Oracle8*i* Enterprise Manager

Oracle8*i* Server

Oracle8*i* Server is the database application software and must be installed on each node in the PDC/O5000.

Refer to the documentation provided with the Oracle8*i* Server software for detailed information.

Oracle8*i* Parallel Server Option

Oracle8*i* Parallel Server Option is the key component in the Oracle8*i* clustering architecture. Oracle8*i* Parallel Server allows the database server to divide its workload among the physical cluster nodes. This is accomplished by running a distinct instance of Oracle8*i* Server on each node in the PDC/O5000.

Oracle8*i* Parallel Server manages the interaction between these instances. Through its Integrated Distributed Lock Manager, Oracle8*i* Parallel Server manages the ownership of database records that are requested by multiple instances.

At a lower level, Oracle8*i* Parallel Server monitors cluster membership. It interacts with the OSDs, exchanging information about the state of each cluster node.

For additional information, refer to:

- *Oracle8i Parallel Server Setup and Configuration Guide*
- *Oracle8i Parallel Server Concepts*
- *Oracle8i Parallel Server Administration, Deployment, and Performance*

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Oracle8*i* Enterprise Manager

Oracle8*i* Enterprise Manager is responsible for monitoring the state of both the database entities and the cluster members. It primarily manages the software components of the cluster. Hardware components are managed with Compaq Insight Manager.

Do not install Oracle8*i* Enterprise Manager on any of the PDC/O5000 nodes. To conserve cluster resources (memory, processes, etc.), it must be installed on a separate server that is running Oracle8*i* and has network access to the cluster nodes. Before installing Oracle8*i* Enterprise Manager, read its documentation to ensure it is installed and configured correctly for an Oracle8*i* Parallel Server environment.

Oracle8*i* Certification

To ensure that Oracle8*i* Parallel Server is used in a compatible hardware environment, Oracle has established a certification process, which is a series of test suites designed to stress an Oracle8*i* Parallel Server implementation and verify stability and full functionality.

All hardware providers who choose to deliver platforms for use with Oracle8*i* Parallel Server must demonstrate the successful completion of the Oracle8*i* Parallel Server for Windows 2000 Certification. Neither Oracle nor Compaq will support any implementation of Oracle8*i* Parallel Server that does not strictly conform to the configurations certified with this process. For a complete list of certified Compaq servers, see the *Compaq Parallel Database Cluster Model PDC/05000 Certification Matrix for Windows 2000* at

www.compaq.com/solutions/enterprise/ha-pdc.html

Application Failover and Reconnection Software

When a network client computer operates in a clustered environment, it must be more resilient than when operating with a stand-alone server. Because a client can access the database through any of the cluster nodes, the failure of the connection to a node does not have to prevent the client from reattaching to the cluster and continuing its work.

Oracle clustering software provides the capability to allow the automatic reconnection of a client and application failover in the event of a node failure.

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To implement this application and connection failover, a software interface between the Oracle software and the client must be written.

Such a software interface would be responsible for detecting when the client's cluster node is no longer available and then connecting the client to one of the remaining, operational cluster nodes.

NOTE: For complete information on how to ensure client auto-reconnect in an Oracle Parallel Server environment, contact your Oracle representative.

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Chapter 4

Cluster Planning

Before connecting any cables or powering on any hardware on your Compaq Parallel Database Cluster Model PDC/O5000 (referred to here as the PDC/O5000), it is important that you understand how all the various cluster components fit together to meet your operational requirements. The major topics discussed in this chapter are:

- Site planning
- Capacity planning for cluster hardware
- Planning cluster configurations for redundant Fibre Channel Fabrics
- Planning cluster configurations for redundant Fibre Channel Arbitrated Loops
- RAID planning
- Planning the grouping of physical disk storage space
- Disk drive planning
- Network planning

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Site Planning

You must carefully select and prepare the site to ensure a smooth installation and a safe and efficient work environment. To select and prepare a location for your cluster, consider the following:

- The path from the receiving dock to the installation area
- Availability of appropriate equipment and qualified personnel
- Space for unpacking, installing, and servicing the computer equipment
- Sufficient floor strength for the computer equipment
- Cabling requirements, including the placement of network and Fibre Channel cables within one room (under the subfloor, on the floor, or overhead) and possibly between rooms
- Client LAN resource planning, including the number of hubs or switches and cables to connect to the cluster nodes
- Environmental conditions, including temperature, humidity, and air quality
- Power, including voltage, current, grounding, noise, outlet type, and equipment proximity

IMPORTANT: Carefully review the power requirements for your cluster components to identify special electrical supply needs in advance.

Capacity Planning for Cluster Hardware

Compaq ProLiant Servers

The number of servers you install in a PDC/O5000 should take into account the levels of availability and scalability your site requires. Start by planning your cluster so that the failure of a single node will not adversely impact cluster operations. For example, when running a two-node cluster, the failure of one node leaves the one remaining node to service all clients. This could result in an unacceptable level of performance.

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Within each server, the appropriate number and speed of the CPUs and memory size are all determined by several factors. These include the types of database applications being used and the number of clients connecting to the servers.

NOTE: Certain restrictions apply to the server models and server configurations that are supported by the Compaq Parallel Database Cluster. For a current list of PDC/O5000-certified servers and details on supported configurations, refer to the *Compaq Parallel Database Cluster Model PDC/O5000 Certification Matrix for Windows 2000*. This document is available on the Compaq website at

www.compaq.com/solutions/enterprise/ha-pdc.html

Planning Shared Storage Components for Redundant Fibre Channel Fabrics

Several key components make up the shared storage subsystem for the PDC/O5000. Each redundant Fibre Channel Fabric in a PDC/O5000 uses the following hardware components:

- Two or more KGPSA-BC PCI-to-Optical Fibre Channel Host Adapters (KGPSA-BC Host Adapters) or KGPSA-CB PCI-to-Optical Fibre Channel Host Adapters (KGPSA-CB Host Adapters) in each node.
- Two or more Compaq StorageWorks Fibre Channel SAN Switches (Fibre Channel SAN Switches), each of which connects all of the cluster nodes to both array controllers in each storage subsystem.
- Compaq StorageWorks Modular Array 8000 Fibre Channel Storage Subsystems or the Compaq StorageWorks Enterprise Modular Array 12000 Fibre Channel Storage Subsystems (MA8000/EMA12000 Storage Subsystems). Each storage subsystem holds up to 72 disk drives.
- Two dual-port Compaq StorageWorks HSG80 Array Controllers (HSG80 Array Controllers) installed in the controller enclosure of each MA8000/EMA12000 Storage Subsystem.

NOTE: For more information about redundant Fibre Channel Fabrics in a PDC/O5000 cluster, see Chapter 2, "Cluster Architecture."

The Fibre Channel SAN Switch is available in two models:

- Fibre Channel SAN Switch 8 (8 ports)
- Fibre Channel SAN Switcb 16 (16 ports)

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To determine which Fibre Channel SAN Switch model is appropriate for a redundant Fibre Channel Fabric in your cluster, you need to know the following:

- Whether you are implementing dual redundancy or quad redundancy in the redundant Fibre Channel Fabric. Dual redundancy requires two host adapters per node and two Fibre Cbannel SAN Switches. Quad redundancy requires four host adapters per node and four Fibre Channel SAN Switches.
- Total number of host adapters in all nodes
- Total number of array controller ports in all of the storage subsystems in the redundant Fibre Channel Fabric

You will need enough switch ports to accommodate the connections from the host adapters to the Fibre Channel SAN Switches and from the Fibre Channel SAN Switches to the array controllers.

The number of storage subsystems and shared disk drives used in a redundant Fibre Channel Fabric PDC/O5000 depends on the amount of shared storage space required by the database, the hardware RAID levels used on the shared storage disks, and the number and storage capacity of disk drives installed in the enclosures. Refer to "Raw Data Storage and Database Size" in this chapter for more details.

NOTE: For improved I/O performance and cluster integrity, as you increase the number of nodes in a PDC/O5000, you should also increase the aggregate bandwidth of the shared storage subsystem by adding more or higher-capacity disk drives.

Planning Shared Storage Components for Redundant Fibre Channel Arbitrated Loops

Several key components make up the shared storage subsystem for the PDC/O5000. Each redundant Fibre Channel Arbitrated Loop (FC-AL) in a PDC/O5000 uses the following hardware components:

- Two or more host adapters in eacb node.
- Two or more Compaq StorageWorks Fibre Cbannel Storage Hubs (Storage Hubs), each of which connects all of the cluster nodes to both array controllers in each storage subsystem.

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- MA8000/EMA12000 Storage Subsystems, each of which holds up to 72 disk drives.
- Two dual-port HSG80 Array Controllers installed in each storage subsystem's controller enclosure.

NOTE: For more information about redundant Fibre Channel Arbitrated Loops (FC-ALs) in a PDC/O5000, see Chapter 2, "Cluster Architecture."

The Storage Hubs are available in two models:

- Storage Hub 7 (7 ports)
- Storage Hub 12 (12 ports)

To determine which Storage Hub model is appropriate for a redundant FC-AL in your cluster, you need to know the following:

- Whether you are implementing dual redundancy or quad redundancy in the redundant FC-AL. Dual redundancy requires two host adapters per node and two Storage Hubs. Quad redundancy requires four host adapters per node and four Storage Hubs.
- Total number of host adapters in all nodes
- Total number of array controller ports in all of the storage subsystems in the redundant FC-AL

You will need enough Storage Hub ports to accommodate the connections from the host adapters to the Storage Hubs and from the Storage Hubs to the array controllers.

The number of storage subsystems and shared disk drives used in a PDC/O5000 redundant FC-AL depends on the amount of shared storage space required by the database, the hardware RAID levels used on the shared storage disks, and the number and storage capacity of disk drives installed in the enclosures. Refer to "Raw Data Storage and Database Size" in this chapter for more details.

NOTE: For improved I/O performance and cluster integrity, as you increase the number of nodes in a PDC/O5000, you should also increase the aggregate bandwidth of the shared storage subsystem by adding more or higher-capacity disk drives.

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Planning Cluster Interconnect and Client LAN Components

PDC/O5000 clusters running Oracle8*i* Parallel Server can use a redundant Ethernet cluster interconnect. A redundant cluster interconnect is required because it provides fault tolerance along the cluster interconnect paths.

Planning an Ethernet Cluster Interconnect

NOTE: Refer to the technical white paper *Supported Ethernet Interconnects for Compaq Parallel Database Clusters Using Oracle Parallel Server* for detailed information about configuring redundant Ethernet cluster interconnects. This document is available at

www.compaq.com/support/techpubs/whitepapers

Before installing the Ethernet cluster interconnect in a PDC/O5000 cluster, review these planning considerations:

- Whether to use two Ethernet switches or two Ethernet hubs for the cluster interconnect. If your cluster will contain or grow to three or more nodes, you must use two Ethernet switches.
- Whether to use two dual-port Ethernet adapters in each node that will connect to both the cluster interconnect and the client LAN or to use separate single-port adapters for the Ethernet cluster interconnect and the client LAN.

Planning the Client LAN

Every client/server application requires a local area network (LAN) over which client machines and servers communicate. In the case of a cluster, the hardware components of the client LAN are no different than in a stand-alone server configuration.

In keeping with the redundant architecture of the cluster interconnect, you may choose to install a redundant client LAN, with redundant Ethernet adapters and redundant Ethernet switches or hubs.

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Planning Cluster Configurations for Redundant Fibre Channel Fabrics

A redundant Fibre Channel Fabric is two or more Fibre Channel SAN Switches installed between host adapters in cluster nodes and array controllers in the shared storage subsystems. Each redundant Fibre Channel Fabric in a PDC/O5000 provides I/O path connections between each cluster node and the two ports on both array controllers in each MA8000/EMA12000 Storage Subsystem. Thus, each node can issue I/O requests to every storageset in the storage subsystems contained in that redundant Fibre Channel Fabric.

A redundant Fibre Channel Fabric increases a PDC/O5000 cluster's availability by providing redundant components along the I/O paths between the cluster nodes and the storage subsystems. If a particular component fails, data communication can continue over an I/O path containing functional components.

To achieve redundancy in Fibre Channel Fabrics, you can implement either a dual redundancy configuration or a quad redundancy configuration.

Planning Dual Redundancy Configurations

A dual redundancy configuration is the minimum allowable configuration that provides redundancy along the I/O paths between the cluster nodes and the storage subsystems. This configuration provides two of each component along the I/O paths. These components include:

- At least two cluster nodes
- Two host adapters in each node
- Two Fibre Channel SAN Switches
- Two dual-port array controllers in each storage subsystem
- Fibre Channel cables and GBIC-SW modules for the connections between the host adapters and the Fibre Channel SAN Switches, and between the Fibre Channel SAN Switches and the array controllers

If a redundant component on one of the I/O paths fails, the cluster nodes can continue to access shared storage through the path containing the surviving component.

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Figure 4-1 shows the correct method for cabling the I/O path components for dual redundancy in a redundant Fibre Channel Fabric. In Figure 4-1, both Fibre Channel SAN Switches connect to port 1 on one array controller and to port 2 on the other array controller in each storage subsystem. If one Fibre Channel SAN Switch fails, the other switch still has access to port 1 on one array controller and port 2 on the other array controller in each storage subsystem. This configuration ensures that the host adapters can still access the full range of LUNs.

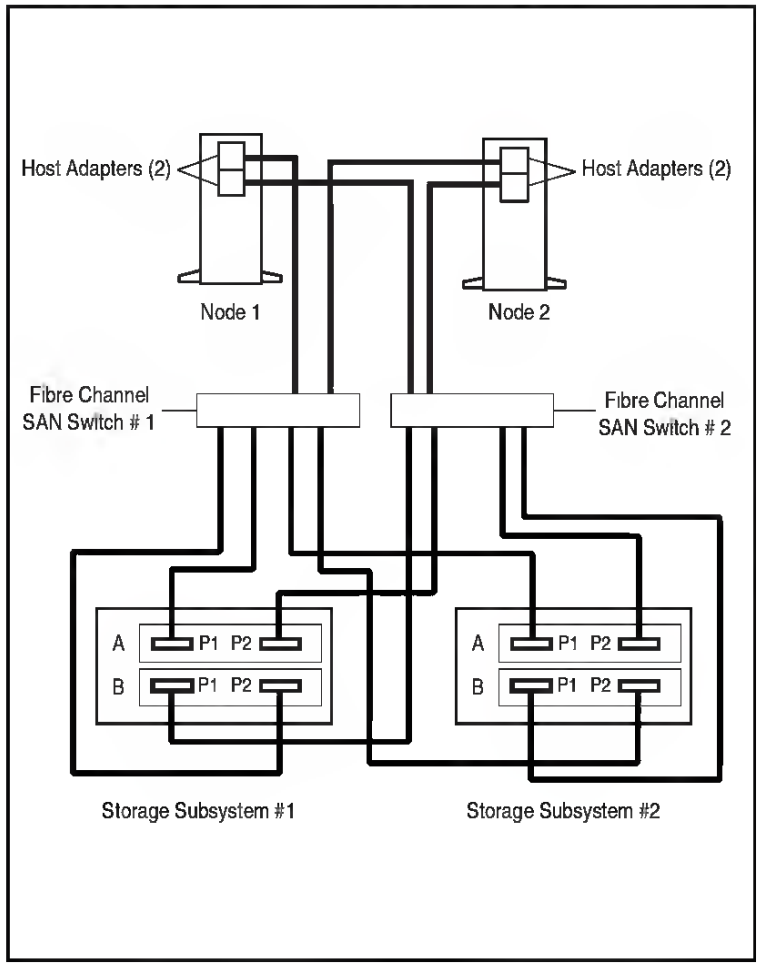

Figure 4-1. Dual redundancy configuration for a redundant Fibre Channel Fabric

See Chapter 2, "Cluster Architecture," for more details on how to configure Fibre Channel Fabrics for dual redundancy.

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Planning Quad Redundancy Configurations

For the highest possible level of I/O path redundancy, you can configure your cluster for quad redundancy. This configuration provides four host adapters in each of at least four nodes and four Fibre Channel SAN Switches for each redundant Fibre Channel Fabric.

The recommended quad redundancy configuration includes these I/O path components:

- At least four cluster nodes
- Four host adapters in each node
- Four Fibre Channel SAN Switches in each redundant Fibre Channel Fabric
- Two dual-port array controllers in each storage subsystem
- Fibre Channel cables and GBIC-SW modules for the connections between the nodes and the Fibre Channel SAN Switches, and between the Fibre Channel SAN Switches and the storage subsystems

In a quad redundancy configuration, both ports on both array controllers in each storage subsystem access the same storagesets. Thus, up to three of the four paths between the controllers and the shared data can fail and the cluster nodes can still access the shared data. In addition, quad redundancy provides continued access to shared storage in the event of multiple component failures in the I/O paths between the nodes and the array controllers. For example, up to three host adapters in a node can fail, or up to three Fibre Channel SAN Switches can fail, and the nodes can still access shared storage over a path containing functioning components.

Figure 4-2 shows an example of a quad redundancy configuration in a redundant Fibre Channel Fabric. In this example, the following connections are made:

- Each of four host adapters in each node connects to the same-numbered Fibre Channel SAN Switch (host adapter 1 to Fibre Channel SAN Switch #1, host adapter 2 to Fibre Channel SAN Switch #2, host adapter 3 to Fibre Channel SAN Switch #3, host adapter 4 to Fibre Channel SAN Switch #4).
- The two odd-numbered Fibre Channel SAN Switches connect to port 1 of the array controllers. Fibre Channel SAN Switch #1 connects to array controller A, port 1 in each storage subsystem. Fibre Channel SAN Switch #3 connects to array controller B, port 1 in each storage subsystem.

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- The two even-numbered Fibre Channel SAN Switches connect to port 2 of the array controllers. Fibre Channel SAN Switch #2 connects to array controller A, port 2 in each storage subsystem. Fibre Channel SAN Switch #4 connects to array controller B, port 2 in each storage subsystem.

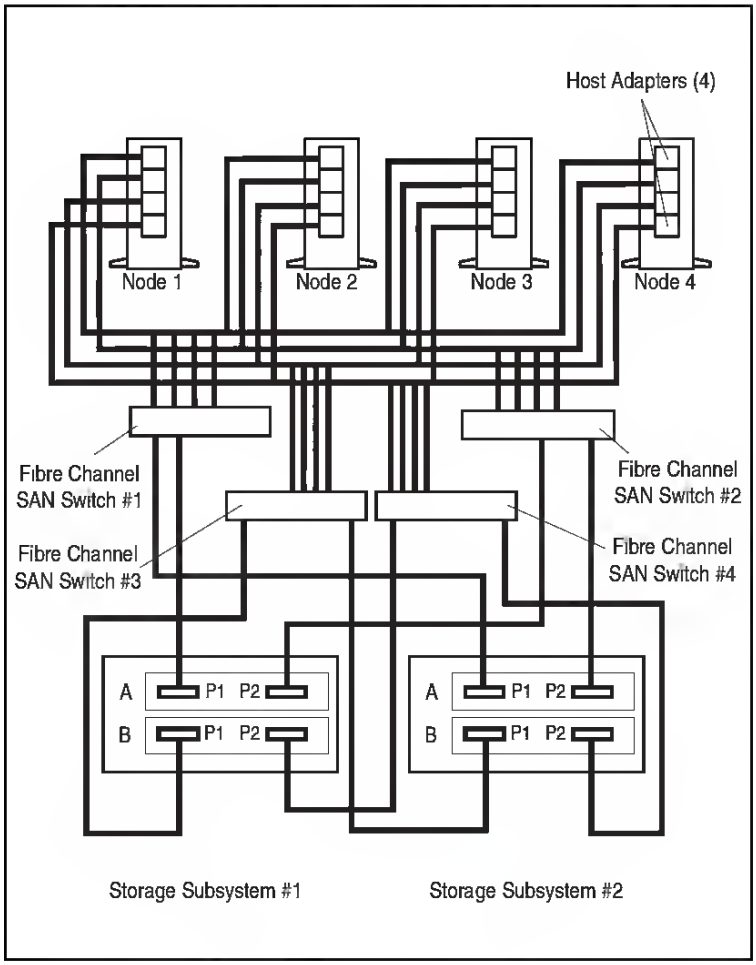

Figure 4-2. Quad redundancy configuration for a redundant Fibre Channel Fabric

A quad redundancy configuration provides greater component availability than a dual redundancy configuration, but requires a greater investment in hardware.

See Chapter 2, "Cluster Architecture," for more details on implementing a quad redundancy configuration in redundant Fibre Channel Fabrics.

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Planning Cluster Configurations for Redundant Fibre Channel Arbitrated Loops

A redundant Fibre Channel Arbitrated Loop (FC-AL) is two or more Storage Hubs installed between host adapters in cluster nodes and array controllers in the shared storage subsystems. Each redundant FC-AL in a PDC/O5000 provides I/O path connections between each cluster node and the two ports on both array controllers in each MA8000/EMA12000 Storage Subsystem. Thus, each node can issue I/O requests to every storageset in the storage subsystems contained in that redundant FC-AL.

A redundant FC-AL increases a PDC/O5000 cluster's availability by providing redundant components along the I/O path between the cluster nodes and the storage subsystems. If a particular component fails, data communication can continue over an I/O path containing functional components.

To achieve redundancy in Fibre Channel Arbitrated Loops, you can implement either a dual redundancy configuration or a quad redundancy configuration.

Planning Dual Redundancy Configurations

A dual redundancy configuration is the minimum allowable configuration that provides redundancy along the I/O paths between the cluster nodes and the storage subsystems. This configuration provides two of each component along the I/O paths. These components include:

- At least two cluster nodes
- Two host adapters in each node
- Two Storage Hubs
- Two dual-port array controllers in each storage subsystem
- Cables and GBIC-SW modules for the connections between the host adapters and the Storage Hubs and between the Storage Hubs and the array controllers

If a redundant component along one of the I/O paths fails, the cluster nodes continue to access shared storage through the path containing the surviving component.

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Figure 4-3 shows the correct method for cabling the I/O path components for dual redundancy in a redundant FC-AL. In Figure 4-3, both Storage Hubs connect to port 1 on one array controller and to port 2 on the other array controller in each storage subsystem. If one Storage Hub fails, the other Storage Hub still has access to port 1 on one array controller and port 2 on the other array controller in each storage subsystem. This configuration ensures that the host adapters can still access the full range of LUNs.

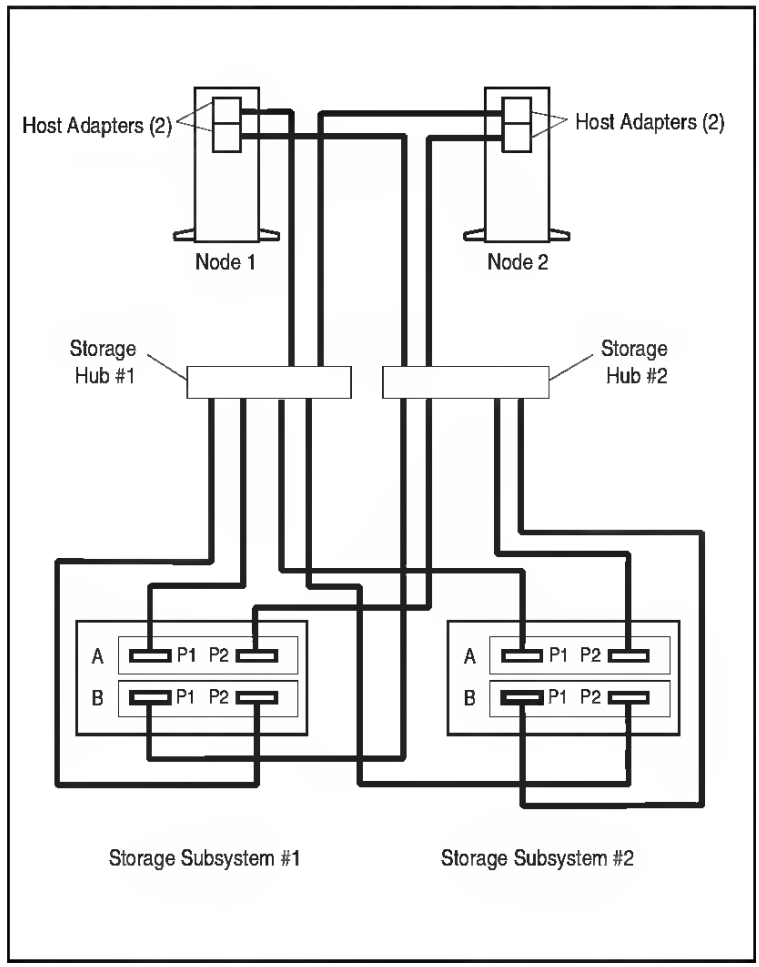

Figure 4-3. Dual redundancy configuration for a redundant FC-AL

See Chapter 2, "Cluster Architecture," for more details on how to configure redundant FC-ALs for dual redundancy.

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Planning Quad Redundancy Configurations

For the highest possible level of I/O path redundancy, you can configure your cluster for quad redundancy. This configuration provides four host adapters in each of at least four nodes and four Storage Hubs for each redundant FC-AL.

The recommended quad redundancy configuration includes these I/O path components:

- At least four cluster nodes
- Four host adapters in each node
- Four Storage Hubs in each redundant FC-AL
- Two dual-port array controllers in each storage subsystem
- Fibre Channel cables and GBIC-SW modules for the connections between the nodes and the switches or hubs, and between the switches or hubs and the storage subsystems

In a quad redundancy configuration, both ports on both array controllers in each storage subsystem access the same storagesets. Thus, up to three of the four paths between the controllers and the shared data can fail and the cluster nodes can still access the shared data. In addition, quad redundancy provides continued access to shared storage in the event of multiple component failures in the I/O paths between the nodes and the array controllers. For example, up to three host adapters in a node can fail, or up to three Storage Hubs can fail, and the nodes can still access shared storage over an I/O path containing functional components.

Figure 4-4 shows an example of a quad redundancy configuration in a redundant FC-AL. In this example, the following connections are made:

- Each of four host adapters in each node connects to the same-numbered Storage Hub (host adapter 1 to Storage Hub #1, host adapter 2 to Storage Hub #2, host adapter 3 to Storage Hub #3, host adapter 4 to Storage Hub #4).
- The two odd-numbered Storage Hubs connect to port 1 of the array controllers. Storage Hub #1 connects to array controller A, port 1 in each storage subsystem. Storage Hub #3 connects to array controller B, port 1 in each storage subsystem.

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- The two even-numbered Storage Hubs connect to port 2 of the array controllers. Storage Hub #2 connects to array controller A, port 2 in each storage subsystem. Storage Hub #4 connects to array controller B, port 2 in each storage subsystem.

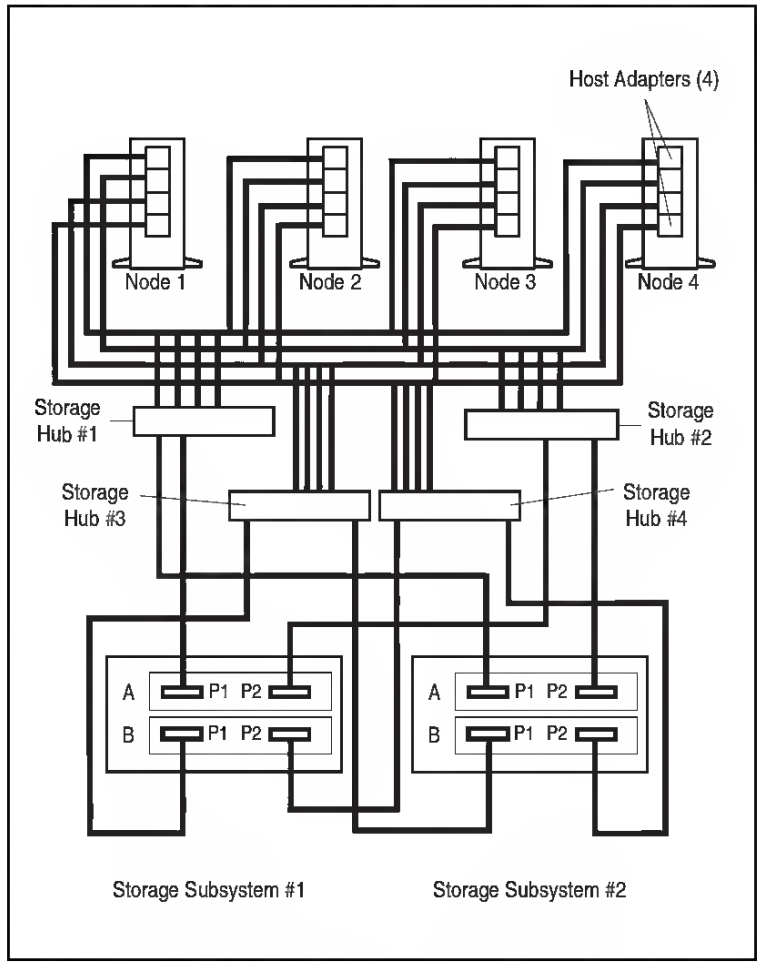

Figure 4-4. Quad redundancy configuration for a redundant FC-AL

Quad redundancy provides an even higher level of availability than dual redundancy. However, it requires a greater investment in hardware.

See Chapter 2, "Cluster Architecture," for more details on how to configure redundant FC-ALs for quad redundancy.

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RAID Planning for the MA8000/EMA12000 Storage Subsystem

Storage subsystem performance is one of the most important aspects of tuning database cluster servers for optimal performance. Efforts to plan, configure, and tune a PDC/O5000 cluster should focus on getting the most out of each disk drive and having an appropriate number of shared storage drives in the cluster. When properly configured, the I/O subsystem should not be the limiting factor in overall cluster performance.

RAID technology provides cluster servers with more consistent performance, higher levels of fault tolerance, and easier fault recovery than non-RAID systems. RAID uses redundant information stored on different disks to ensure that the cluster can survive the loss of any disk in the array without affecting the availability of data to users.

RAID also uses the technique of *striping*, which involves partitioning each drive's storage space into units ranging from a sector (512 bytes) up to several megabytes. The stripes of all the disks are interleaved and addressed in order.

In this cluster, each node is connected to shared storage disk drive arrays that are housed in MA8000/EMA12000 Storage Subsystem disk enclosures. When planning the amount of shared storage for your cluster, you must consider the following:

- The number of shared storage subsystems (MA8000/EMA12000 Storage Subsystems) you intend to install in the PDC/O5000 cluster. You install dedicated shared storage subsystems to each redundant FC-AL or redundant Fibre Channel Fabric in your cluster. You cannot share storage subsystems between redundant FC-ALs or between redundant Fibre Channel Fabrics The greater the number of redundant FC-ALs or redundant Fibre Channel Fabrics present, the more storage subsystems you can install in cluster.
- The number of redundant FC-ALs or redundant Fibre Channel Fabrics allowed in a cluster, in turn, depends upon the maximum number of host adapters that can be installed in the ProLiant server model you will be using. Refer to the server documentation for this information.
- The appropriate number of shared storage subsystems in a cluster is determined by the performance requirements of your cluster.

Refer to "Planning Shared Storage Components for Redundant Fibre Channel Fabrics" and "Planning Shared Storage Components for Redundant Fibre Channel Arbitrated Loops" in this chapter for more information.

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The PDC/O5000 implements RAID at the hardware level, which is faster than software RAID. When you implement RAID on shared storage arrays, you use the hardware RAID to perform such functions as making copies of the data or calculating checksums. To implement the RAID sets, use the Compaq StorageWorks Command Console (SWCC) or the Command Line Interface (CLI) window for the HSG80 Array Controllers.

NOTE: Do not use the software RAID offered by the operating system to configure your shared storage disks.

Supported RAID Levels

RAID provides several fault-tolerant options to protect your cluster's shared data. However, each RAID level offers a different mix of performance, reliability, and cost.

The MA8000/EMA12000 Storage Subsystem and HSG80 Array Controllers used with the PDC/O5000 supports these RAID levels:

- RAID 1
- RAID 0+1
- RAID 3/5
- RAID 5

For RAID level definitions and information about configuring hardware RAID, refer to the following:

- Refer to the information about RAID configuration contained in the StorageWorks documentation provided with the HSG80 Array Controller.
- Refer to the Compaq white paper *Configuring Compaq RAID Technology for Database Servers,* #ECG 011/0598, available at the Compaq website at

  www.compaq.com
- Refer to the various white papers on Oracle8*i*, which are available at the Compaq *ActiveAnswers*™ website at

  www.compaq.com/activeanswers/

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Raw Data Storage and Database Size

Raw data storage is the amount of storage available before any RAID levels have been configured. It is called raw storage because RAID volumes require some overhead. The maximum size of a database stored in a RAID system will always be less than the amount of raw data storage available, except for RAID 0, where no storage overhead is required.

To calculate the amount of raw data storage in a cluster, determine the total amount of shared storage space that will be available to the cluster. To do this, you need to know the following:

- The number of storage subsystems in the cluster
- The number and storage capacities of the physical disk drives installed in each storage subsystem

Add together the planned storage capacity contained in all storage subsystems to calculate the total amount of raw data storage in the PDC/O5000. The maximum amount of raw data storage in an MA8000/EMA12000 Storage Subsystem depends on what type of disk drives you install in the subsystem. For example, an MA8000/EMA12000 Storage Subsystem with six disk enclosures and 12 9.1-GB Ultra2 disk drives per enclosure provides a maximum storage capacity of .65 TB. Using the 18.2-GB Ultra3 disk drives provides a maximum storage capacity of 1.3 TB.

The amount of shared disk space required for a given database size is affected by the RAID levels you select and the overhead required for indexes, I/O buffers, and logs. Consult your Oracle representative for further details.

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Selecting the Appropriate RAID Level

Many factors will affect the RAID levels you select for your cluster database. These include the specific availability, performance, reliability, and recovery capabilities required from the database. Each cluster must be evaluated individually by qualified personnel.

The following general guidelines apply to RAID selection for a PDC/O5000 cluster using Oracle8*i* Parallel Server:

- Oracle recommends that some form of disk fault tolerance be implemented in the cluster.
- In order to ease the difficulty of managing dynamic space allocation in an OPS raw volume environment, Oracle recommends the creation of "spare" raw volumes that can be used to dynamically extend tablespaces when the existing datafiles approacb capacity. The number of these spare raw volumes should represent from 10 to 30 percent of the total database size. To allow for effective load balancing, the spares should be spread across a number of disks and controllers. The database administrator should decide, on a case by case basis, which spare volume to use based on which volume would have the least impact on scalability (for both speedup and scaleup).

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Planning the Grouping of Physical Disk Storage Space

Figure 4-5 shows an example of how the physical storage space for one 12-drive array in an MA8000/EMA12000 Storage Subsystem disk enclosure could be grouped for an Oracle8*i* Parallel Server database.

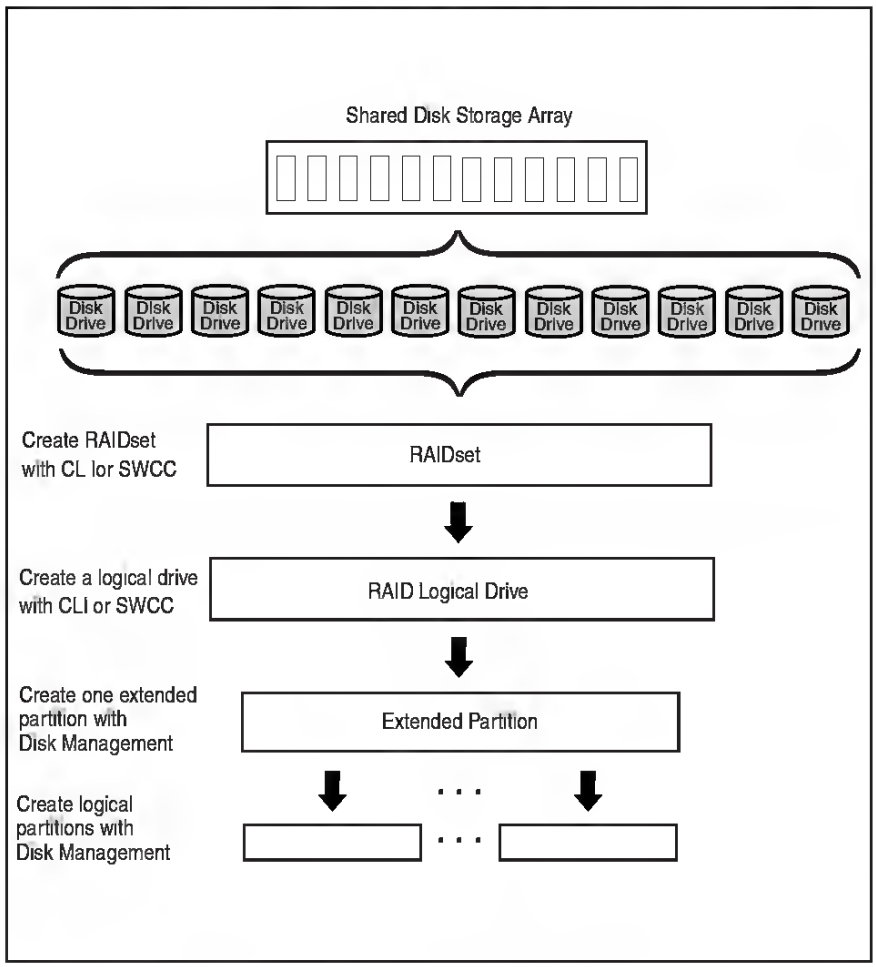
Shared Disk Storage Array
Disk Drive
Create RAIDset with CL lor SWCC
RAIDset
Create a logical drive with CLI or SWCC
RAID Logical Drive
Create one extended partition with Disk Management
Extended Partition
Create logical partitions with Disk Management

Figure 4-5 MA8000/EMA12000 Storage Subsystem disk grouping for a PDC/05000 cluster

Each MA8000/EMA12000 Storage Subsystem contains up to six disk enclosures. You are advised to configure all the drives in each enclosure as a single separate logical drive. As Figure 4-5 shows, this requires that you create a RAID set, create one logical drive, create one extended partition, then create

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logical partitions. For detailed information about these procedures, refer to "Configuring a Storageset" and "Creating Partitions" in Chapter 5, "Installation and Configuration."

You use either the CLI window for the HSG80 Array Controllers or the Compaq StorageWorks Command Console (SWCC) to create, configure, and partition the logical disks. While the CLI window provides very detailed control over the MA8000/EMA12000 Storage Subsystem, the SWCC replicates most of the CLI window functions in a graphic form and provides a more user-friendly tool for executing CLI commands.

IMPORTANT: To perform partitioning, all required drivers must already be installed for each server. These include the Compaq KGPSA driver for the host adapters, the HSG80 Array Controller (HSZDISK) driver, and the Secure Path (RAIDISK.SYS) driver.

Disk Drive Planning

Nonshared Disk Drives

Nonshared disk drives, or local storage, operate the same way in a cluster as they do in a single-server environment. These drives can be in the server drive bays or in an external storage enclosure. As long as they are not accessible by multiple servers, they are considered nonshared.

Treat non-shared drives in a clustered environment as you would in a non-clustered environment. In most cases, some form of RAID is used to protect the drives and aid in restoration of a failed drive. Since the Oracle Parallel Server application files are stored on these drives, it is recommended that you use hardware RAID.

Hardware RAID is the recommended solution for RAID configuration because of its superior performance. For the PDC/O5000, hardware RAID for the shared storage subsystem can be implemented using StorageWorks Command Console (SWCC) or the Command Line Interface (CLI) window for the array controllers.

Shared Disk Drives

Shared disk drives are contained in disk enclosures that are accessible to each node in a cluster. It is recommended that you use hardware RAID levels 1, 0+1, 3/5, or 5 on your shared disk drives.

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If a logical drive is configured with a RAID level that does not support fault tolerance (for example, RAID 0), then the failure of the shared disk drives in that logical drive will disrupt service to all Oracle databases that are dependent on that disk drive. See "Selecting the Appropriate RAID Level" earlier in this chapter.

The array controllers are equipped with RAID. The array controller RAID is configured with RAID storageset commands issued from the CLI window or from the SWCC.

The array controller software (ACS) monitors the status of the shared disk drives. If it detects a drive failure, it puts that drive in the failed set. From the StorageWorks CLI or SWCC GUI, you can monitor the status of shared storage disk drives and failed sets. A failed drive is displayed from the SWCC GUI with an "X" marked over it. For further information, refer to "Replacing a Failed Drive in a Storage Subsystem" in Chapter 6, "Cluster Management."

Network Planning

Windows 2000 Advanced Server Host Files for an Ethernet Cluster Interconnect

When an Ethernet cluster interconnect is installed between cluster nodes, the Compaq operating system dependent modules (OSDs) require a unique entry in the hosts and lmhosts files located at %SystemRoot%\system32\drivers\etc for each network port on each node.

Each node needs to be identified by the IP address assigned to the Ethernet adapter port used by the Ethernet cluster interconnect and by the IP address assigned to the Ethernet adapter port used by the client LAN. The suffix "_san" stands for system area network.

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The following list identifies the format of the hosts and lmhosts files for a four-node PDC/O5000 cluster with an Ethernet cluster interconnect:

```
IP address      node1
IP address      node1_san
IP address      node2
IP address      node2_san
IP address      node3
IP address      node3_san
IP address      node4
IP address      node4_san
```

Client LAN

Physically, the structure of the client network is no different than that used for a nonclustered configuration.

To ensure continued access to the database when a cluster node is evicted from the cluster, each network client should have physical network access to all of the cluster nodes.

Software used by the client to communicate to the database must be able to reconnect to another cluster node in the event of a node eviction. For example, clients connected to cluster node1 need the ability to automatically reconnect to another node if cluster node1 fails.

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Chapter 5

Installation and Configuration

Reference Materials for Installation

The Compaq Parallel Database Cluster PDC/O5000 (referred to here as the PDC/O5000) is a combination of several individually available products. As you set up your cluster, have the following materials available during installation. You will find references to them throughout this chapter.

- User guides for the clustered Compaq ProLiant servers
- Installation posters for the clustered ProLiant servers
- Installation guides for the cluster interconnect and client LAN interconnect adapters
- Compaq SmartStart Installation Poster
- Compaq SmartStart and Support Software CD
- *Microsoft Windows 2000 Advanced Server Administrator's Guide*
- Microsoft Windows 2000 Advanced Server CD with Service Pack 1 or later
- StorageWorks documentation provided with the MA8000/EMA12000 Storage Subsystem
- MA8000/EMA12000 Solution Software CD
- KGPSA Windows 2000 Device Driver and Download Utility diskette
- HSG80 Solution for Windows 2000 CD

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- StorageWorks Secure Path Software CD
- Compaq Parallel Database Cluster Clustering Software for Oracle8*i* on Microsoft Windows 2000 CD
- Oracle8*i* Enterprise Edition CD
- *Oracle8i Parallel Server Setup and Configuration Guide*
- Other documentation for Oracle8*i*

Installation Overview

Installation and setup of your PDC/O5000 involves this sequence of tasks.

- Installing the hardware, including:
  - Cluster nodes
  - Host adapters
  - Cluster interconnect and client LAN adapters
  - Ethernet Switches or bubs
  - Fibre Channel SAN Switches or Storage Hubs
  - MA8000/EMA12000 Storage Subsystem controller and disk enclosure components, including power supplies, I/O modules, disk drives, array controllers, and cache memory modules
- Installing and configuring operating system software, including:
  - SmartStart 4.9 or later
  - Windows 2000 Advanced Server with Service Pack 1 or later
- Setting up and configuring an MA8000/EMA12000 Storage Subsystem, including:
  - Designating a server as a maintenance terminal
  - Configuring a storage subsystem for a redundant Fibre Channel Fabric
  - Configuring a storage subsystem for a redundant Fibre Channel Arbitrated Loop (FC-AL)
  - Verifying array controller properties
  - Configuring a storageset

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- Installing and configuring Secure Path for Windows 2000, including:
  - Installing host adapter drivers
  - Installing the Fibre Channel Software Setup (FCSS) utility
  - Installing the Secure Path Driver, Secure Path Agent, and Secure Path Manager
  - Installing the optional Compaq StorageWorks Large LUN utility
  - Specifying preferred_path units
  - Creating partitions
- Installing and configuring the Compaq operating system dependent modules (OSDs), including:
  - Using Oracle Universal Installer to install OSDs for an Ethernet cluster interconnect
- Installing and configuring Oracle software, including:
  - Oracle8*i* Enterprise Edition with Oracle8*i* Parallel Server Option
- Installing Object Link Manager
- Verifying the hardware and software installation, including:
  - Cluster interconnect and client LAN communications
  - Access to shared storage from all nodes
  - Client access to the Oracle8*i* database
- Power distribution and sequencing guidelines

Installing the Hardware

Setting Up the Nodes

Physically preparing the nodes (servers) for a cluster is not very different than preparing them for individual use. You will install all necessary adapters and insert all internal hard disks. You will attach network cables and plug in SCSI and Fibre Channel cables. The primary difference is in setting up the shared storage subsystem.

Set up the hardware on one node completely, then set up the rest of the nodes identically to the first one. Do not load any software on any cluster node until all the hardware has been installed in all cluster nodes. Before loading

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software, review the section in this chapter entitled "Installing Operating System Software" to understand the idiosyncrasies of configuring a cluster.

NOTE: Certain restrictions apply to the server models and server configurations that are supported by the Compaq Parallel Database Cluster. For a current list of PDC-certified servers and details on supported configurations, refer to the *Compaq Parallel Database Cluster Model PDC/O5000 Certification Matrix for Windows 2000.* This document is available on the Compaq website at

www.compaq.com/solutions/enterprise/ha-pdc.html

While setting up the physical hardware, follow the installation instructions in your *Compaq ProLiant Server Setup and Installation Guide* and in your Compaq ProLiant Server Installation Poster.

Installing the KGPSA-BC and KGPSA-CB Host Adapters

To install KGPSA-BC PCI-to-Optical Fibre Channel Host Adapters (KGPSA-BC Host adapter) or KGPSA-CB PCI-to-Optical Fibre Channel Host Adapters (KGPSA-CB Host Adapter) in your servers, follow the installation instructions in your *Compaq ProLiant Server Setup and Installation Guide* and in your Compaq ProLiant Server Installation Poster.

Install the host adapters into the same PCI slots in each server. If possible, the host adapter should be placed into PCI slots on different PCI buses (if the server has more than one PCI bus). For example, in a ProLiant 6500 server, host adapters could be installed into PCI slots 4 and 7. This distributes the load from the storage subsystem. You would then install two host adapter into PCI slots 4 and 7 in all other cluster nodes.

Installing GBIC-SW Modules for the Host Adapters

Each host adapter ships with two GBIC-SW modules. Verify that one GBIC-SW module is installed in each host adapter and another module is installed into the active port for that host adapter on its Storage Hub or Fibre Channel SAN Switch. Each end of the Fibre Channel cable connecting a host adapter to a Storage Hub or Fibre Channel SAN Switch plugs into a GBIC-SW module.

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Cabling the Host Adapters to Fibre Channel SAN Switches or Storage Hubs

Each redundant Fibre Channel Fabric requires at least two Fibre Channel SAN Switches and each redundant FC-AL requires at least two Storage Hubs. For detailed cabling guidelines, refer to the sections entitled "I/O Path Configurations for Redundant Fibre Channel Fabrics" and "I/O Path Configurations for Redundant Fibre Channel Arbitrated Loops" in Cbapter 2, "Cluster Architecture."

To cable the host adapters to the Fibre Channel SAN Switches or Storage Hubs:

1. Using Fibre Channel cables, connect host adapter #1 in each server to Fibre Channel SAN Switcb #1 or Storage Hub #1.
2. Using Fibre Channel cables, connect host adapter #2 in each server to Fibre Channel SAN Switch #2 or Storage Hub #2.
3. Repeat steps 1 and 2 for all other host adapters in each server and additional Fibre Channel SAN Switches or Storage Hubs. Connect like-numbered host adapters across servers to the same Fibre Channel SAN Switch or Storage Hub.

Figure 5-1 shows two host adapter in two servers connected to two Fibre Channel SAN Switches or Storage Hubs.

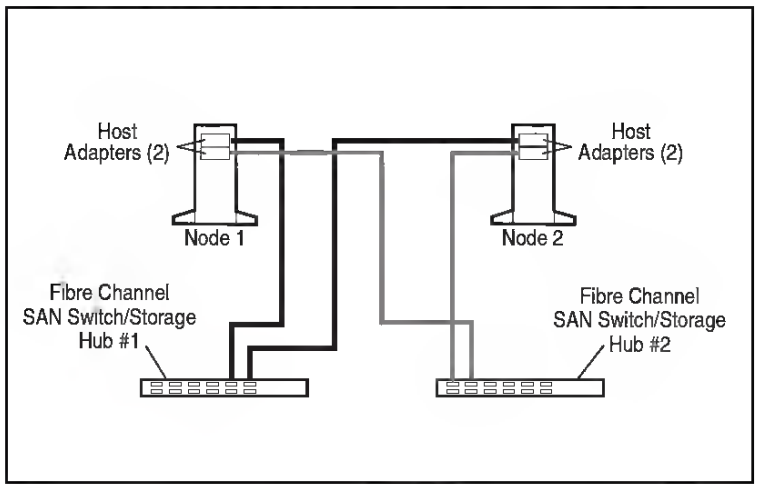

Figure 5-1. Connecting host adapters to Fibre Channel SAN Switches or Storage Hubs

For more information about Fibre Channel SAN Switches and Storage Hubs, refer to the Compaq documentation provided with them.

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Installing the Cluster Interconnect Adapters

A PDC/O5000 running Oracle8*i* software has an Ethernet cluster interconnect. Both redundant and non-redundant cluster interconnects can be used.

Ethernet Cluster Interconnect

For a non-redundant Ethernet cluster interconnect, install one single-port or dual-port Ethernet adapter into each cluster node. For a redundant Ethernet cluster interconnect, install two single-port or two dual-port Ethernet adapters into each cluster node.

If you need specific instructions on how to install an Ethernet adapter, refer to the documentation of the Ethernet adapter you are installing or refer to the user guide of the ProLiant server you are using.

Refer to the section "Cabling An Ethernet Cluster Interconnect" for more information about building an Ethernet cluster interconnect.

Installing the Client LAN Adapters

Unlike other clustering solutions, the PDC/O5000 does not allow transmission of intra-cluster communication across the client LAN. All such communication must be sent over the cluster interconnect.

Install a NIC into each cluster node for the client LAN. Configuration of the client LAN is defined by site requirements. To avoid a single point of failure in the cluster, install a redundant client LAN.

If you need specific instructions on how to install an adapter, refer to the documentation for the adapter you are installing or refer to the user guide of the ProLiant server you are using.

Installing GBIC-SW Modules for the Array Controllers

Each MA8000/EMA12000 Storage Subsystem's controller enclosure contains two dual-port HSG80 Array Controllers and ships with four GBIC-SW modules. Verify that one GBIC-SW module is installed in both port connectors on each array controller. Install another GBIC-SW module into the two ports on the Storage Hub or Fibre Channel SAN Switch associated with each array controller.

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To install GBIC-SW modules:

1. Verify that a GBIC-SW module is installed into both ports on each array controller.
2. Insert a GBIC-SW module into the correct port on each Storage Hub or Fibre Channel SAN Switch (two modules for each array controller).
3. Repeat steps 1 and 2 for all other MA8000 Storage Subsystems.

Cabling an Ethernet Cluster Interconnect

The following components are used in a redundant Ethernet cluster interconnect:

- Two Ethernet adapters in each cluster node
- Ethernet cables and switches or hubs
  - For two-node PDC/O5000 clusters, you can use two 100-Mbit/sec Ethernet switches or hubs with cables to connect the servers.
  - For PDC/O5000 clusters with three or more nodes, you use two 100-Mbit/sec Ethernet switches connected by Ethernet cables to a separate Ethernet adapter in each server.

NOTE: In a redundant Ethernet cluster configuration, one Ethernet crossover cable must be installed between the two Ethernet switches or hubs that are dedicated to the cluster interconnect.

To connect two or more nodes in a redundant Ethernet cluster interconnect:

1. Insert the ends of two Ethernet cables into two Ethernet adapter ports designated for the cluster interconnect.
2. Connect the other end of one Ethernet cable to an Ethernet hub or switch. Connect the other end of the second Ethernet cable to the second Ethernet hub or switch.
3. Repeat steps 1 and 2 for all other nodes in the cluster.
4. Install one crossover cable between the Ethernet hubs or switches.

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Figure 5-2 shows the redundant Ethernet cluster interconnect components used in a PDC/O5000 with two or more nodes.

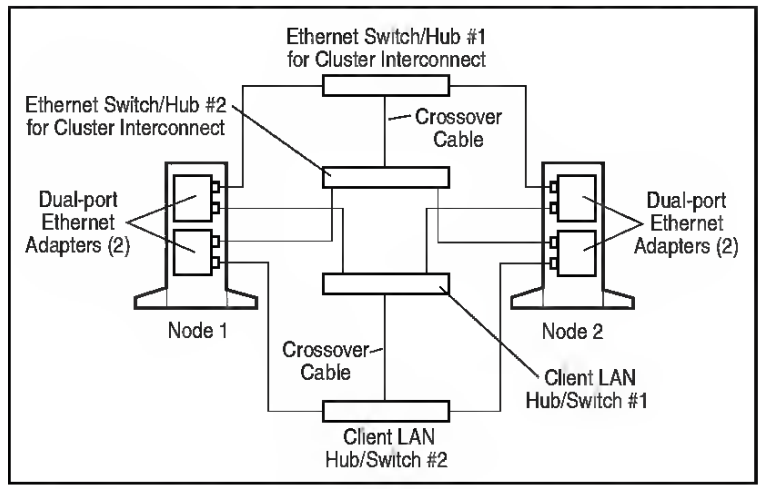

Figure 5-2. Redundant Ethernet cluster interconnect for a two-node PDC/O5000 cluster

These components include two dual-port Ethernet adapters in each cluster node. The top port on each adapter connects by Ethernet cable to one of two Ethernet switches or hubs provided for the cluster interconnect. The bottom port on each adapter connects by Ethernet cable to the client LAN for the cluster. A crossover cable is installed between the two Ethernet switches or hubs used in the Ethernet cluster interconnect.

For clusters of three or more nodes using a redundant Ethernet cluster interconnect, Compaq requires that you use two Ethernet 100-Mbit/sec switches to maintain good network performance across the cluster. If there are only two nodes in a cluster, you can use either Ethernet hubs or switches and standard Ethernet cables to connect the nodes.

For more information on configuring Ethernet connections in a redundant or non-redundant cluster interconnect, including enabling failover from one Ethernet path to another, see *Supported Ethernet Interconnects for Compaq Parallel Database Clusters Using Oracle Parallel Server* at

www.compaq.com/support/techpubs/whitepapers

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Cabling the Client LAN

You can use any TCP/IP network to connect to a client LAN. The following procedure contains instructions for cabling an Ethernet client LAN.

To cable an Ethernet client LAN:

1. Insert one end of an Ethernet cable into an Ethernet adapter port designated for the client LAN in a cluster node.
2. If you are using a recommended dual-port Ethernet adapter for the cluster interconnect, connect the client LAN to the empty port.
3. If you are using a recommended single-port adapter for the cluster interconnect, connect the client LAN to the port on the embedded adapter or to another single-port Ethernet adapter.
4. Connect the node to the client LAN by inserting the other end of the client LAN Ethernet cable to a port in the Ethernet hub or switch.
5. Repeat steps 1 through 4 for all other cluster nodes.

Redundant Client LAN

If you elect to install a redundant Ethernet client LAN, you must provide two single-port Ethernet adapters or one dual-port Ethernet adapter in each cluster node for the client LAN. Two Ethernet hubs or switches and one Ethernet crossover cable must be installed between the Ethernet hubs or switches. Installing redundant crossover cables directly between the nodes is not allowed.

For information on configuring Ethernet connections in a redundant client LAN, including enabling failover from one Ethernet path to another, see *Supported Ethernet Interconnects for Compaq Parallel Database Clusters Using Oracle Parallel Server* at

www.compaq.com/support/techpubs/whitepapers

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Installing Hardware Into an MA8000/EMA12000 Storage Subsystem

Installing Hardware into a Controller Enclosure

The controller enclosure for the MA8000/EMA12000 Storage Subsystem houses the two HSG80 Array Controllers, one cache module for each controller, an environmental monitoring unit (EMU), one or two power supplies, and three dual-speed fans. In addition, the controller enclosure houses the six I/O modules that connect the enclosure's six SCSI buses to up to six disk enclosures.

For detailed instructions on installing hardware components in a controller enclosure, refer to the documentation provided with the MA8000/EMA12000 Storage Subsystem.

Installing Hardware into a Disk Enclosure

Each disk enclosure houses up to 12 or 14 form factor hard disk drives, depending on the number of SCSI buses connected to the enclosure's I/O module. Disk enclosures using a single-bus I/O module can contain up to 12 disk drives. Disk enclosures using both connectors on a dual-bus I/O module can contain up to 14 disk drives (7 per SCSI bus). When you have more than three disk enclosures in your subsystem, they must all use single-bus I/O modules, for a maximum of 72 disk drives in each MA8000/EMA12000 Storage Subsystem.

Each disk enclosure also contains redundant power supplies, an EMU, and two variable-speed blowers. A single-bus or dual-bus I/O module connects each disk enclosure by UltraSCSI cable to one I/O module in the controller enclosure.

For detailed instructions on installing hardware components in a disk enclosure, refer to the documentation provided with the MA8000/EMA12000 Storage Subsystem.

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Cabling the Controller Enclosure to Disk Enclosures

Compaq recommends using the shortest UltraSCSI cable length possible to connect disk enclosures to the controller enclosure. The maximum supported cable length is 2 meters (6.6 ft). Refer to the documentation provided with your storage subsystem for further information.

As Figure 5-3 shows, both HSG80 Array Controllers (A and B) connect to six I/O modules in the controller enclosure. UltraSCSI cables are installed between these I/O modules in the controller enclosure and one I/O module in each disk enclosure.

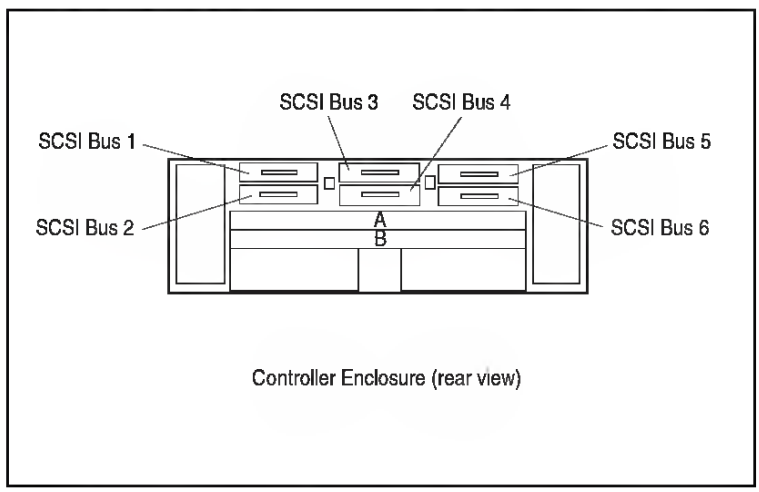

Figure 5-3. SCSI bus numbers for I/O modules in the controller enclosure

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Figure 5-4 shows UltraSCSI cables installed between a controller enclosure and three disk enclosures. When three or fewer disk enclosures are present in a storage subsystem, you can install one dual-bus I/O module in each disk enclosure.

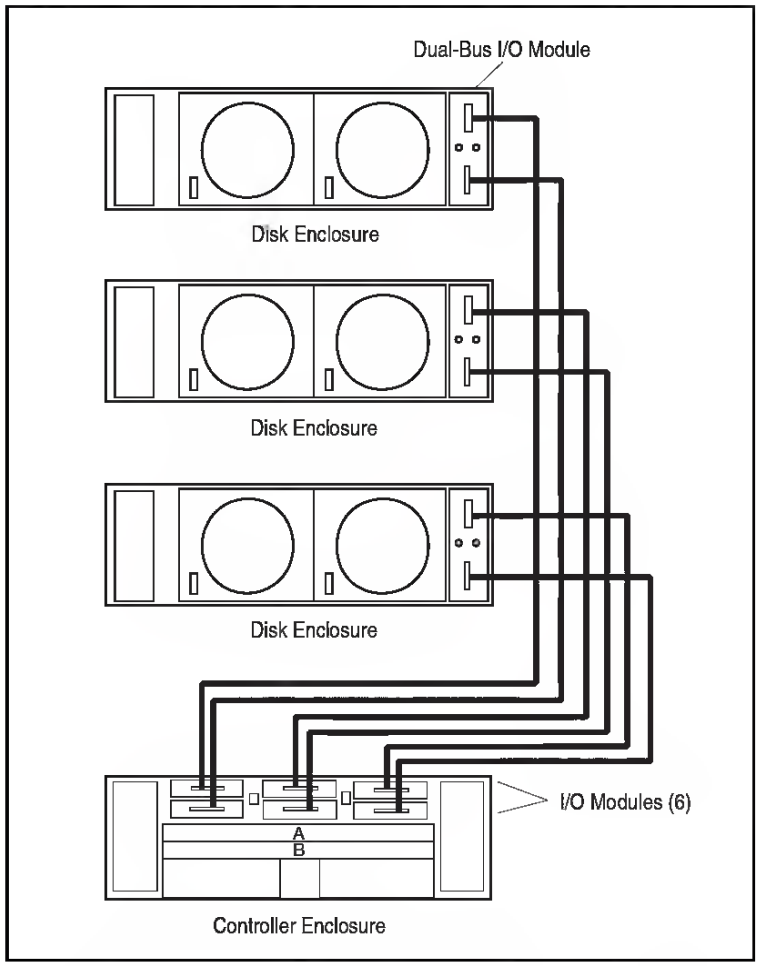

Figure 5-4. UltraSCSI cabling between a controller enclosure and three disk enslosures

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Figure 5-5 shows UltraSCSI cables installed between a controller enclosure and six disk enclosures. When four or more disk enclosures are present in a storage subsystem, you must install one single-bus I/O module in each disk enclosure.

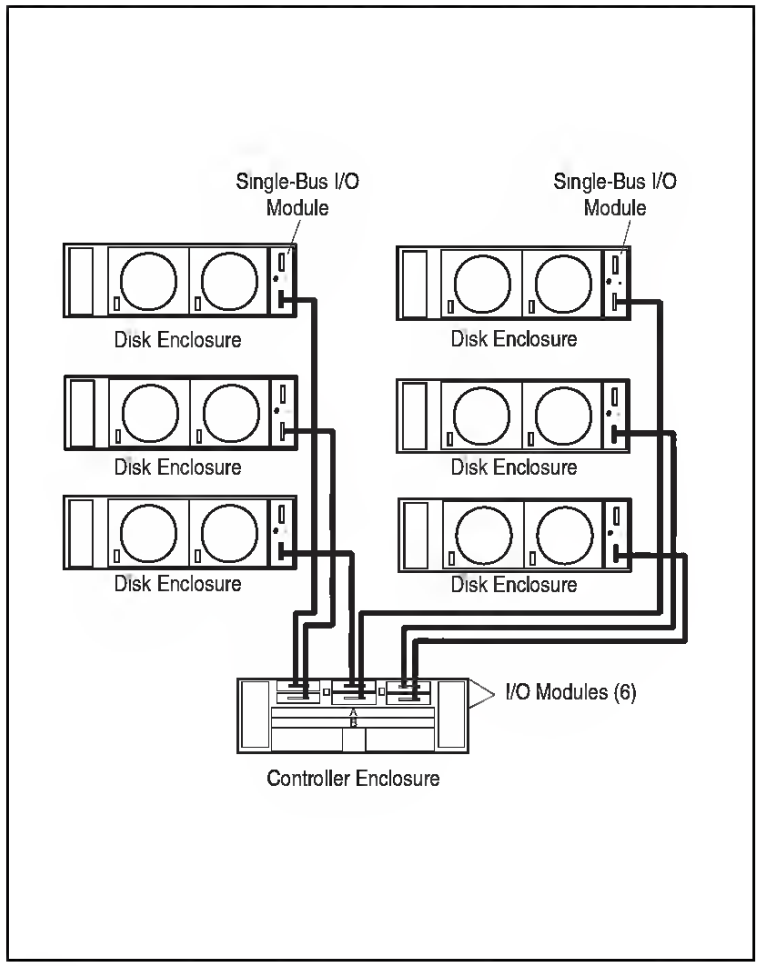

Figure 5-5. UltraSCSI cabling between a controller enclosure and six disk enclosures

Cabling EMUs to Each Other

For information about connecting the EMUs between enclosures in an MA8000/EMA12000 Storage Subsystem and between different subsystems, refer to the Compaq documentation provided with the storage subsystem.

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Cabling Array Controllers to Fibre Channel SAN Switches

In a PDC/O5000 with a redundant Fibre Channel Fabric, a dual redundancy configuration is the minimum allowable configuration that provides redundancy along the I/O paths. This configuration provides two of each component along the I/O paths. These include at least two nodes, two host adapters in each node, and two Fibre Channel SAN Switches.

Figure 5-6 shows the correct method for cabling the I/O path components in a dual redundancy configuration. In this example, both Fibre Channel SAN Switches connect to port 1 on one array controller and to port 2 on the other array controller in each MA8000/EMA12000 Storage Subsystem. If one Fibre Channel SAN Switch fails, the other switch still has access to port 1 on one array controller and port 2 on the other array controller in each storage subsystem. This ensures that the host adapters can still access the full range of LUNs.

IMPORTANT: Connect lower-numbered array controller ports to lower-numbered Fibre Channel SAN Switch ports. This will simplify path identification as defined by the Secure Path Manager utility. For example, if port 1 of a controller is connected to switch port 3, controller port 2 should be connected to switch port 4 or higher.

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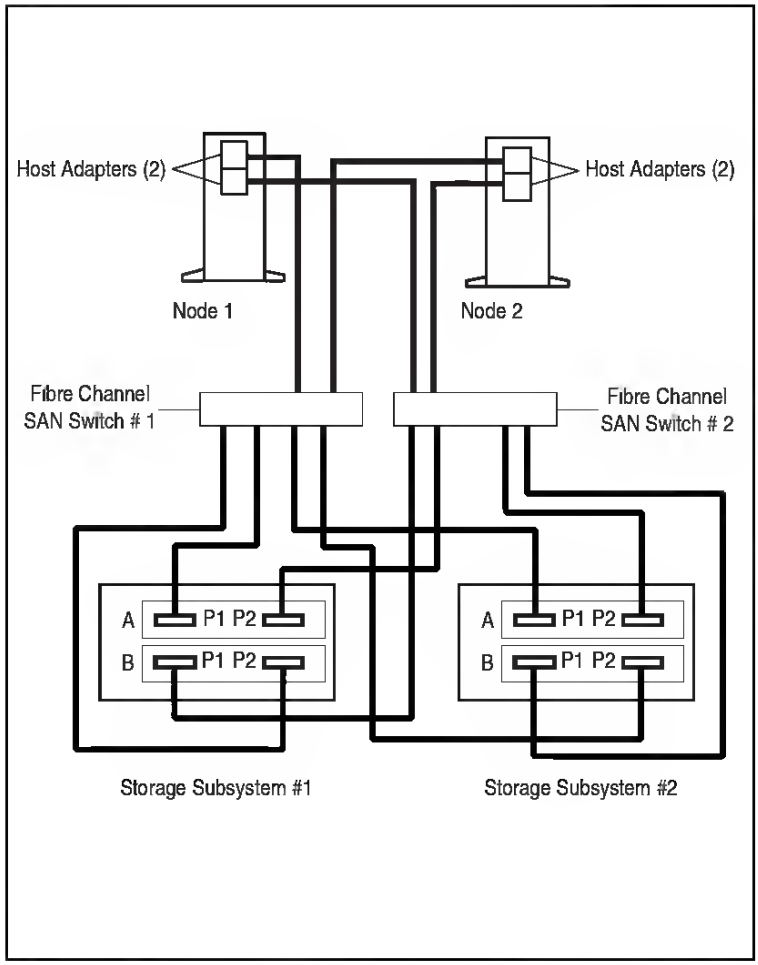

Figure 5-6. Dual redundancy configuration for a redundant Fibre Channel Fabric

Cabling Array Controllers to Storage Hubs

In a PDC/O5000 with a redundant FC-AL, a dual redundancy configuration is the minimum allowable configuration that provides redundancy along the I/O paths. This configuration provides two of each component along the I/O paths. These include at least two nodes, two host adapters in each node, and two Storage Hubs.

Figure 5-7 shows the correct method for cabling the I/O path components in a dual redundancy configuration. In this example, both Storage Hubs connect to port 1 on one array controller and to port 2 on the other array controller in each MA8000/EMA12000 Storage Subsystem. If one Storage Hub fails, the other

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Storage Hub still has access to port 1 on one array controller and port 2 on the other array controller in each storage subsystem. This ensures that the host adapters can still access the full range of LUNs.

This option provides path redundancy between the Storage Hubs and the array controllers.

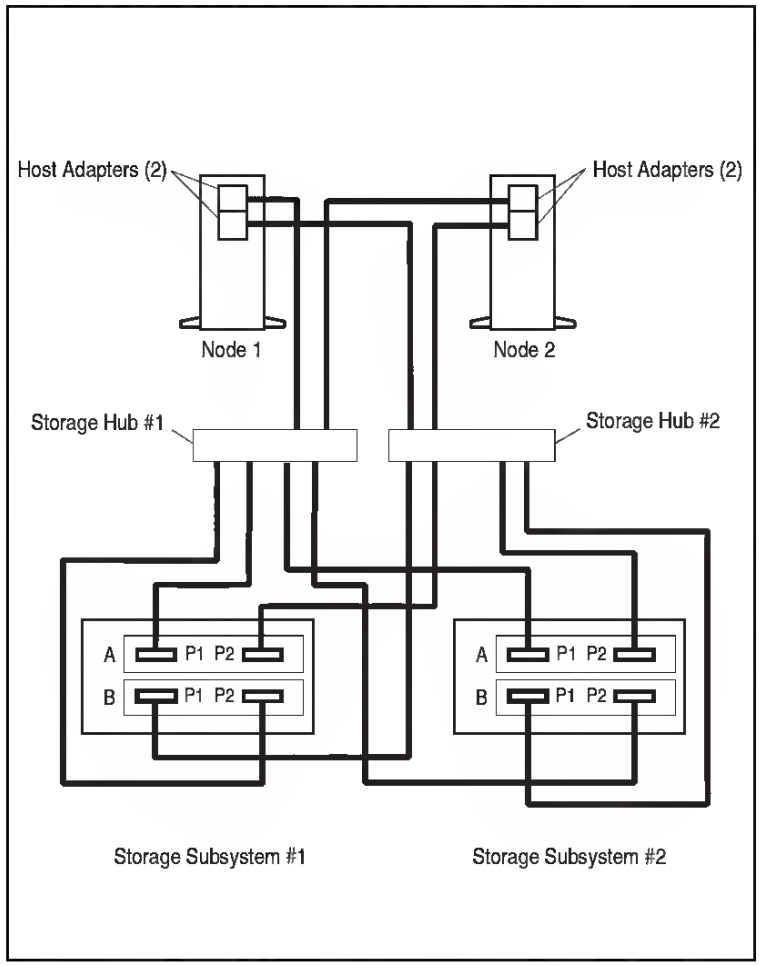

Figure 5-7. Dual redundancy configuration for a redundant FC-AL

Installing Operating System Software

You will follow an automated procedure using Compaq SmartStart to install the operating system software on the cluster nodes for the PDC/O5000.

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Guidelines for Clusters

Installing clustering software requires several specific steps and guidelines that might not be necessary when installing software on a single server. Be sure to read and understand the following items before proceeding with the specific software installation steps in "Automated Installation Steps."

- Because a PDC/O5000 contains multiple servers, be sure you have sufficient software licensing rights to install Windows 2000 Advanced Server software applications on each server.
- Be sure your servers, host adapters, Fibre Channel SAN Switches or Storage Hubs, and array controllers are installed and cabled before you install the software.
- When you set up an Ethernet cluster interconnect, be sure to select **TCP/IP** as the network protocol. The Ethernet cluster interconnect should be on its own subnet.

IMPORTANT: The IP addresses of the Ethernet cluster interconnect must be static, not dynamically assigned by DHCP.

- Be sure to set up unique IP addresses and node names for each cluster node (server) in the hosts and lmhosts files located at %SystemRoot%\system32\drivers\etc.
  - One IP address and node name is for the cluster interconnect, and the other IP address and node name is for the client LAN. Both entries are required for each node in the cluster.
  - After setting up these file entries, be sure to restart the node so it picks up the correct IP addresses.

Automated Installation Using SmartStart

CAUTION: Automated installation using SmartStart assumes that it is being installed on new servers. If there is any existing data on the servers, it will be destroyed.

You will need the following during SmartStart installation for Oracle8*i*:

- SmartStart and Support Software CD 4.9 or later
- Microsoft Windows 2000 Advanced Server with Service Pack 1 or later
- SmartStart Installation Poster
- Server Profile Diskette

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Cluster-Specific SmartStart Installation

The SmartStart Installation Poster describes the general flow of configuring and installing software on a single server. The installation for a PDC/O5000 will be very similar.

Automated Installation Steps

You will perform the following automated installation steps to install operating system software on every node in the cluster.

1. Power up the following cluster components in this order:
   - MA8000/EMA12000 Storage Subsystem
   - HSG80 Array Controller
   - Storage Hubs, FC-AL Switches, or Fibre Channel SAN Switches
   - Ethernet hubs or switches
2. Power up a cluster node and put the SmartStart and Support Software CD into the CD-ROM drive.
3. Select the **Assisted Integration** installation path.
4. When prompted, insert the Server Profile diskette into the floppy disk drive.
5. Select **Windows 2000 Advanced Server** as the operating system.
6. Continue with the Assisted Integration installation. Windows 2000 Advanced Server is installed as part of this process.

   NOTE: For clustered servers, take the default for Automatic Server Recovery (ASR) and select **standalone** as the server type.

   NOTE: When prompted to use the Array Configuration Utility, it is only necessary to configure the shared drives during the first node's setup. When configuring the other nodes, the utility shows the results of the shared drives configured during the first node's setup.

   NOTE: Do not install Microsoft Cluster Server.

7. From **Start**, select **Settings** and then select **Network and Dial-up Connections**. Select the first connection and right click. Select **Properties**. Select the Internet Protocol (TCP/IP) box and click **OK.**

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8. Double-click on **TCP/IP** and the **Internet Protocol (TCP/IP) Properties** screen is displayed. Enter the IP address as appropriate for each of the port connections.

9. Enter unique IP addresses and node names for each node in the hosts and lmhosts files located at %SystemRoot%\system32\drivers\etc. Record this information:

   - For an Ethernet cluster interconnect, one IP address and node name is for the redundant cluster interconnect, and the other IP address and node name is for the client LAN. For example, **node1** for the client LAN and **node1_san** for the cluster interconnect. (The "_san" stands for system area network.)

   Due to the complexity of Windows 2000 Advanced Server and multiple-NIC servers, you need to verify that the correct IP addresses are assigned to the correct ports/NICs and that the Ethernet cables are connected to the correct ports. If IP addresses are not assigned to the correct port, Oracle software and external programs cannot communicate over the proper network link. The next step describes how to perform this verification.

10. Verify that the IP addresses for the client LAN and cluster interconnect are correctly assigned by pinging the machine host name. (Find this name by selecting the **Network ID** tab on the **System Properties** menu in the System Control Panel.) The IP address returned by the ping utility is one of the IP addresses you specified; it is the IP address that Windows 2000 Advanced Server assigned to the client LAN.

11. If the ping command does not return the IP address you specified in the **TCP/IP Properties** dialog box for the client LAN port and you are using Service Pack 1 or later:

    a. Double-click the **Network and Dial-up Connections** icon in the Control Panel. From the **Advanced** menu, click **Advanced Settings**. A list of Ethernet connections are shown. The first on the list is the **Primary Connection**.

    b. Select all protocols in the **Show Bindings for** scroll box.

    c. Click + (plus sign) next to the TCP/IP protocol. A list of all installed Ethernet NICs appears, including the slot number and port number of each. Windows 2000 Advanced Server uses the NIC at the top of the list for the client LAN.

    d. Change the binding order of the NICs to put the NIC you specified for the client LAN at the top of the list. Find the client LAN NIC in the list and select it.

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e. With the client LAN NIC selected, click **Move Up** to position this NIC to the top of the list.

f. Click **OK** on the dialog box and restart the node when prompted.

IMPORTANT: Record the cluster interconnect node name, the client LAN node name, and the IP addresses assigned to them. You will need this information later when installing Compaq OSDs.

---

12. If you are installing node1, open Windows 2000 Advanced Server Disk Management to create extended disk partitions and logical partitions within the extended partitions on all MA8000/ Arrays. (If you are installing a node other than node1, skip to step 13.)

    Create all disk partitions on the RA4000/RA4100 Arrays from node1, select **Commit Changes Now** from the **Partition** menu, and restart the node.

    For more information on creating partitions, see the *Oracle8i Parallel Server Setup and Configuration Guide*.

13. If you are installing a node other than node1, open Disk Management to verify that the same shared disk resources are seen from this node as are seen from other installed nodes in the cluster. If they are not, restart the node and review the shared disk resources again.

14. Repeat steps 2 through 13 on all other cluster nodes.

15. After configuring all nodes in the cluster, verify the client LAN connections by pinging all nodes in the cluster from each cluster node. Use the client LAN node name, (for example, **node1**) with the ping command. If you are using a redundant Ethernet cluster interconnect, verify the cluster interconnect connections by using the Ethernet cluster interconnect node name (for example, **node1_san**) with the ping command.

16. Power down the cluster nodes and client LAN Ethernet switches or hubs.

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Setting up and Configuring an MA8000/EMA12000 Storage Subsystem

Designating a Server as a Maintenance Terminal

To set up and configure an MA8000/EMA12000 Storage Subsystem in a PDC/O5000, you must connect a cluster server (node) to an HSG80 Array Controller in that storage subsystem through the controller's maintenance port. This provides a maintenance terminal from which to configure the storage subsystem. You must also connect the second array controller to the server through its maintenance port so you can configure it for I/O path failover.

NOTE: Only one server in the cluster should be designated as the maintenance server.

To connect the maintenance server to both array controllers in the storage subsystem:

1. Connect the RJ12 connector on a communications cable to the maintenance port on an array controller.
2. Connect the 9-pin serial connector on the communications cable to either the COM1 or COM2 port on the server.
3. Connect the RJ12 connector on a second communications cable to the maintenance port on the second array controller.
4. Connect the 9-pin serial connector on the communications cable to the unused COM port on the server.

NOTE: Be careful to note which serial port is connected to which array controller. You will need this information when setting up the communications program and configuring the controller.

Powering On the MA8000/EMA12000 Storage Subsystem

To power on a storage subsystem:

1. Power on one of the Fibre Channel SAN Switches or Storage Hubs that are connected by Fibre Channel cables to the storage subsystem.

IMPORTANT: Do not power on the other Fibre Channel SAN Switches or Storage Hubs until after installing the Secure Path software.

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2. Connect each storage subsystem's controller enclosure and disk enclosures to a guaranteed power source.
3. Power on all storage subsystem enclosure components as specified in the user documentation for the storage subsystem.
4. Power up all servers in the cluster.

The storage subsystem is ready to operate when the green LED in the pushable RESET button on the array controller blinks at a rate of one time per second. This takes about one minute to occur.

Installing the StorageWorks Command Console (SWCC) Client

Install the SWCC Client software on the node designated as the maintenance server.

To install the SWCC Client:

1. Insert the MA8000/EMA12000 Solution Software CD into the CD-ROM drive.
2. Run Windows Explorer.
3. Navigate to the folder *DRIVE_LETTER*:\SWCC\CLIENT (where *DRIVE_LETTER* identifies the letter for the CD-ROM drive).
4. Select **Intel Client**. Double-click on **Setup.**
5. Follow the setup wizard instructions to complete the installation.
6. Restart the server.

Configuring a Storage Subsystem for Secure Path Operation

Each new MA8000/EMA12000 Storage Subsystem is preconfigured with specific parameters. You may need to change these parameters, depending on which Fibre Channel SAN topology and cluster configuration you use. This subsection reviews the steps required to make these changes.

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To set port topologies and Arbitrated Loop Physical Address (ALPA) settings for both array controllers, perform these steps:

NOTE: Refer to the Compaq StorageWorks documentation for more detailed information about changing the port topology settings.

1. Click on the Windows taskbar **Start** button.
2. Select **Program**, **Command Console**, **CLI Window.**
3. Click on the CLI window to display the Connection Selection dialog box.
4. Select **Serial** and click **OK** to display the Connect Serial dialog box.
5. Select the COM port to which the top array controller is connected.
6. Select a baud rate of 9600.
7. Click **Connect** to display the CLI window.
8. Press **Enter** to initialize communications.
9. Repeat steps 1 through 8 for the other COM port and the bottom array controller connection.
10. From the CLI window type the following and press **Enter:**

    set this node_id=xxxx-xxxx-xxxx-xxxx xx

    (xxxx-xxxx-xxxx-xxxx is the bar-coded World Wide ID located in the controller enclosure. The final xx is the two-digit checksum on the same label.)

    NOTE: The "other" controller will shut down and must be manually restarted by momentarily pressing the reset button on the controller's front panel. Wait for two minutes for the controller to boot before proceeding.

11. Configure both array controllers for multibus failover mode.
    a. Type the following command and press **Enter:**

       set nofailover

    b. Type the following command and press **Enter:**

       set multibus_failover copy=this_controller

    c. Wait two minutes for the controllers to reset.

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d. Verify that both controllers are in multibus failover mode by entering the following commands and viewing the results:

show this_controller

and

show other_controller

e. Close the CLI window.

NOTE: If you are unable to connect with the array controller, reset the controller by pressing the flashing RESET LED button on the controller, and retry connection after two minutes.

12. If the storage subsystem is installed in a redundant Fibre Channel Fabric, set the array controller port topology for "fabric." From the Command Line Interface (CLI), type the following and press **Enter:**

NOTE: Refer to the StorageWorks documentation for more details on changing the port topology settings.

set this_controller port_1_topology=fabric

set this_controller port_2_topology=fabric

set other_controller port_1_topology=fabric

set other_controller port_2_topology=fabric

13. If the storage subsystem is installed in a redundant Fibre Channel Arbitrated Loop (FC-AL), type the following and press **Enter:**

NOTE: Refer to the StorageWorks documentation for more details on changing the port topology and Arbitrated Loop Physical Address (ALPA) settings.

set this_controller port_1_topology=offline

set other_controller port_1_topology=offline

set this_controller port_1_al_pa= *alpa address of this_controller port_1*

set other_controller port_1_al_pa= *alpa address of other_controller port_1*

set this_controller port_1_topology=loop_hard

set other_controller port_1_topology=loop_hard

set this_controller port_2_topology=offline

set other_controller port_2_topology=offline

set this_controller port_2_al_pa= *alpa address of this_controller port_2*

set other_controller port_2_al_pa= *alpa address of other_controller port_2*

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set this_controller port_2_topology=loop_hard

set other_controller port_2_topology=loop_hard

IMPORTANT: The ALPA addresses of port 1 on both array controllers must be identical; the ALPA addresses of port 2 on both array controllers must be identical.

Use only the specified hexadecimal numerals for the ALPA addresses. For the array controllers, first use the middle-range ALPA addresses. When middle range ALPA addresses are no longer available, use the higher-range ALPA addresses. If neither is available, use the lower-range ALPA addresses. Make sure that you do not use an ALPA address recommended for the KGPSA-BC Host adapter in the "Installing the FCSS Utility" section of this chapter. Lower-range ALPA addresses have a higher priority than middle range addresses.

The middle-range ALPA addresses that you can use are:

4A, 4B, 4C, 4D, 4E, 51, 52, 53, 54, 55, 56, 59, 5A, 5C, 63, 65, 66, 67, 69, 6A, 6B, 6C, 6D, 6E, 71, 72, 73, 74, 75, 76, 79, 7A, 7C, 80, 81, 82, 84, 88, 8F, 90, 97, 98, 9B, 9D, 9E, 9F, A3, A5, A6, A7, A9, AA, AB, AC

The higher-range ALPA addresses that you can use are:

AD, AE, B1, B2, B3, B4, B5, B6, B9, BA, BC, C3, C5, C6, C7, C9, CA, CB, CC, CD, CE, D1, D2, D3, D4, D5, D6, D9, DA, DC, E0, E1, E2, E4, E8, EF

The lower-range ALPA addresses that you can use are:

01, 02, 04, 08, 0F, 10, 17, 18, 1B, 1D, 1E, 1F, 23, 25, 26, 27, 29, 2A, 2B, 2C, 2D, 2E, 31, 32, 33, 34, 35, 36, 39, 3A, 3C, 43, 45, 46, 47, 49

14. Restart the array controllers.

    a. If you have a separate CLI window open for each controller, type the following in both CLI windows and press **Enter:**

       restart this_controller

    b. If there is one CLI window open for both controllers, type the following and press **Enter:**

       restart other_controller

       restart this_controller

15. Wait a few minutes for the array controllers to restart.

16. Type the following in the top controller CLI window and press **Enter:**

    show this_controller

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17. If "this_controller" is in a redundant Fibre Channel Fabric, verify the following:
    a. Port_1_topology=fabric
    b. Port_2_topology=fabric
18. If "this_controller" is in a redundant FC-AL, verify the following:
    a. Port_1_topology=Loop Hard (Loop Up)
    b. Port_1_AL_PA=ALPA address you entered for port_1 of this_controller
    c. Port_2_Topology=Loop Hard (Loop Up)
    d. Port_2_AL_PA=ALPA address you entered for port_2 of this_controller
19. Type the following and press **Enter:**

    ```
    show other_controller
    ```

20. If "other_controller" is in a redundant Fibre Channel Fabric, verify the following:
    a. Port_1_topology=fabric
    b. Port_2_topology=fabric
21. If "other_controller" is in a redundant FC-AL, verify the following:
    a. Port_1_topology=Loop Hard (Loop Up)
    b. Port_1_AL_PA=ALPA address you entered for port_1 of other_controller
    c. Port_2_Topology=Loop Hard (Loop Up)
    d. Port_2_AL_PA=ALPA address you entered for port_2 of other_controller
22. Type the following and press **Enter** in the top controller CLI window:

    ```
    set this mirrored_cache
    ```

    Both array controllers flush their cache and start mirroring each other's cache. Both controllers then reset themselves.

Discovering Shared Physical Disks

The physical disk drives installed in the storage subsystem's disk enclosures need to be discovered by the top array controller in the controller enclosure.

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To discover the disk drives:

1. From the CLI window, type the following and press **Enter:**

   run config

2. Wait a few minutes for the array controller to scan and discover the installed disk drives.
3. Once the access LED on each drive has blinked, press **Enter** to return to the command prompt in the CLI window.
4. Type the following and press **Enter:**

   show devices

5. Verify the devices discovered are consistent with the installed disk drives.

   The disk drives will be named in the DISK##### format. Refer to the Compaq StorageWorks documentation for the naming conventions for storage subsystem devices.

6. Close the CLI window.

Verifying Array Controller Properties

Displaying SCSI Devices in the Devices Windowpane

1. Click on the Windows taskbar **Start** button.
2. Select **Program, Command Console, HSG80 Storage Window.**
3. Select **Serial Communication** and click **OK.**
4. Select baud rate of 9600 and click **Connect.**

   NOTE: If you receive a pop-up window reading "Error scanning subsystem," wait two minutes and retry the connection.

SWCC finds installed devices and displays them in a grid.

Verifying Controller Properties

1. Double-click a controller icon in the Storage Window to display Controller Properties. Click on the tabs of the **Controller Properties** screen to confirm that the values in Table 5-1 are set.

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Table 5-1
Controller Properties

Description	Values
General	Allocation class: 0 SCSI version: SCSI-2
Host Ports	Host Port 1 Requested Topology: Loop Hard
	Host Port 1 Requested Port Address: (user defined)
	Host Port 1 Actual Port Address: (user defined)
	Host Port 2 Requested Topology: Loop Hard
	Host Port 2 Requested Port Address: (user defined)
	Host Port 2 Actual Port Address: (user defined)
Cache	Cache flush time (seconds): 10
	Respond to internal cache battery condition: selected
Communications LUN	Confirm that the screen is grayed out (disabled); if not, return to the "Oisable Communication LUN" section.
Connections	Operating System: Windows 2000
	Unit Offset: 0 for Port 1
	(Rename the default connection names to reflect your configuration. For example, SVR1TOP1, for node 1, top controller, port 1. See "Renaming the Oefault Connection Names" in this chapter.)
Battery	Confirm that the battery is fully charged.

2. Repeat step 1 to verify controller properties for the second array controller.
3. Click **OK** to close the Controller Properties window.

Renaming the Default Connection Names

Each KGPSA-BC or KGPSA-CB Host Adapter installed in a PDC/O5000 cluster node is automatically assigned a default connection name to identify its connection to a port on an array controller. You must change these default connection names to the format SVR*n*TOP*n* or SVR*n*BOT*n* required for this PDC.

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To change the default connection names:

1. From CLI, issue the **show connection** command to display connection names and other connection information. The default connection names are listed under the "Connection Name" column.
2. For each host adapter, determine the correct new connection name using the format SVR*n*TOP*n* or SVR*n*BOT*n*, where SVR*n* identifies the node number, TOP*n* identifies the port number (1 or 2) in the top array controller, and BOT*n* identifies the port number (1 or 2) in the bottom array controller.
3. From CLI, issue the **rename** command to change each default connection name to the PDC format. For example, you would rename the connection names for host adapter in Node1 as follows:

   SVR1TOP1

   SVR1TOP2

   SVR1BOT1

   SVR1BOT2

When an installed host adapter has to be replaced, the default connection name for the new host adapter must also be changed to the PDC connection name format. For details, refer to Chapter 6, "Cluster Management."

Configuring a Storageset

You must perform each of the steps in "Configuring a Storageset" for every MA8000/EMA12000 Storage Subsystem in the cluster.

To configure a storageset:

1. Select **Storage** in the HSG80 Storage Window menu line. Select **Add Virtual Disk** to begin step 1 of the Add Virtual Disk Wizard.

   NOTE: A virtual disk is also known as a logical drive.

2. Select a RAID level setting. Click **Next** for step 2 of the wizard.

   Supported RAID levels are: RAID1, RAID0+1, RAID3/5, and RAID5.

   NOTE: If the disks are being used for the first time, a dialog box appears prompting you to initialize the disks.

3. Select the devices you want to include in the virtual disk by clicking on the disks listed in the Available Storage window.

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4. Click **Next** for step 3 of the wizard.
5. Select the maximum capacity for the virtual disk.

IMPORTANT: Secure Path requires maximum capacity partitions.

---

6. Click **Next** for step 4 of the wizard.
7. Enter the virtual disk name.
   - If the optional Compaq StorageWorks Large LUN utility is installed on your cluster, Windows 2000 recognizes D0 through D63 as the virtual disks attached to port 1 of the array controller. Virtual disks D100 through D163 attach to port 2. Distribute the LUNs evenly across all four array controller ports.
   - If the Large LUN utility is not installed, Windows 2000 recognizes D0 through D7 as the virtual disks attached to port 1 of the array controller. Virtual disks D100 through D107 attach to port 2. Distribute the LUNs evenly across all four array controller ports.
8. If the Large LUN utility is installed, do not assign unit offsets to any connections. If the Large LUN utility is not installed, define an offset for the disks associated with port 2 of the array controller. For example, to define an offset for virtual disk D100, you would enter:

IMPORTANT: If the disks associated with port 2 are different from those associated with port 1, then you must define an offset value for the port 2 disks. If the disks associated with port 1 and 2 are the same, then no offset value needs to be assigned to the port 2 disks.

---

set *connection-name* unit_offset = 100

If you do not know the connection name, enter:

show *connection*

9. Verify that the **Save controller configuration to virtual disk** checkbox is selected.
10. Indicate that the virtual disk is to communicate with all nodes in the cluster by selecting **All** in the Host ID Access scroll box.
11. Click **Next** for step 5 of the wizard.

    Step 5 of the wizard displays your choices.

    NOTE: If you are not satisfied with your choices, return to the applicable Wizard step using the Back button. When you are satisfied with your choices, click **Finish.**

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12. Click **Finish** to create the virtual disk.

    The **Storage** window displays the virtual disk you created. The hourglass on the disk icon indicates that the storageset is being initialized. The drives you used to create the RAID set are highlighted in the Devices window.

13. Repeat steps 1 through 12 to create other virtual disks.

14. Wait for the virtual disk initialization to complete before proceeding. This can take several hours, depending on the size and RAID level of the virtual disk created.

15. Close the **Storage** window.

Verifying Access

To verify access to all virtual disks (units):

1. Click on the Windows taskbar **Start** button.
2. Select **Program**, **Command Console**, **CLI Window.**
3. Click on **CLI Window** to display the **Connection Selection** dialog box.
4. Select **Serial** and click **OK** to display the **Connect Serial** dialog box.
5. Select the COM port (the port to which an array controller is connected).
6. Select a baud rate of 9600.
7. Click **Connect** to display the CLI window.
8. Click on CLI window to display the **Connection Selection** dialog box.
9. Press **Enter** to initialize communications.
10. Verify that the ACCESS parameter for each unit is set to ALL by typing the following and pressing **Enter:**

    ```
    show units full
    ```

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11. If not, type the following and press **Enter** for other units (virtual disks) as necessary:

    set *unit-number* enable_access_path=ALL

    Example: Set D1 enable_access_path=ALL

12. Close the CLI window.
13. Restart all nodes in the cluster.

NOTE: To complete storageset configuration, you must create partitions on the virtual disks using Disk Management. While you can perform this step now, it is recommended you do it after completing Secure Path software installation.

If you create partitions now, Disk Management will show double images of all virtual disks, which can be confusing. If you create partitions after installing Secure Path software, Disk Management shows the correct number of virtual disks.

Installing Secure Path Software for Windows 2000

If you have installed more than one MA8000/EMA12000 Storage Subsystem in your PDC/O5000:

- For the first storage subsystem in the PDC/O5000, perform all of the steps listed in this section. The steps in "Installing the Secure Path Drivers, Secure Path Agent, and Secure Path Manager" are performed only for the first storage subsystem.
- For every other storage subsystem in the PDC/O5000, repeat all of the steps in this section except those in "Installing the Secure Path Drivers, Secure Path Agent, and Secure Path Manager."

Overview of Secure Path Software Installation

The following subsections give an overview of the software configuration procedures required for your Secure Path storage environment. For detailed procedures, refer to the *Compaq StorageWorks Secure Path for Windows 2000 on RAID Array 4000/4100 Version 3.1.*

- Install the host adapter drivers
- Install the Fibre Channel Software Setup (FCSS) utility

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- Install the Secure Path software (Secure Path drivers, Secure Path Agent, and Secure Path Manager)
- Specify the preferred_paths of the storagesets (units) to the array controllers
- Create extended partitions

After performing these procedures in sequence, the software configuration of your Secure Path storage environment will be complete.

Description of the Secure Path Software

Secure Path for Windows 2000 consists of two software components that are installed individually. The components are:

- Server software (Raidisk filter driver, RAIDisk driver and SecurePathAgent)
- Client software (Secure Path Manager GUI)

Secure Path for Windows 2000 is managed by a client/server management application that requires TCP/IP to be installed. You must install the Secure path drivers and Secure path agent on all cluster nodes.

You install the Secure Path Manager on each node in the cluster but run it from one cluster node. Although running it from one node minimizes network traffic; having it installed on all of the cluster nodes allows you to run it from another node if the node running Secure Path Manager is evicted from the cluster.

Installing the Host Adapter Drivers

To install the host adapter drivers:

1. From the Start menu, select **Programs**. Open **Administrative Tools.**
2. Select **Computer Management.**
3. Double-click on **System Tools.**
4. Double-click on **Display Adapters.**
5. Double-click on Compaq LP6000/LP7000/LP8000. A **Properties** screen appears.

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6. Select the **Driver** tab. Click **Update** driver. The Update Device Driver Wizard appears.
7. Select **Display a list of the know drivers for tbe device so I can cboose a specific driver.**
8. Select the driver and click **Have Disk.**
9. Insert the KGPSA Windows 2000 Device Driver and Download Utility into the diskette drive.
10. To specify the path, type A:\ and click **OK.**
11. Restart the node.
12. Repeat steps 1 through 11 for each host adapter.

Installing the Fibre Channel Software Setup (FCSS) Utility

IMPORTANT: It is recommended you run this utility before any New Technology File System (NTFS) volumes are created on the MA8000/EMA12000 Storage Subsystem. If NTFS volumes exist, running the FCSS utility and rebooting may reassign drive letters. Refer to the StorageWorks documentation for details on drive letter reassignment.

The FCSS utility installs the RAIDISK driver and other shared storage subsystem device drivers required for Windows 2000 clusters and sets the Arbitrated Loop Physical Address (ALPA) and registry parameters.

To install the FCSS utility:

1. Insert the Solutions Software for ACS CD into your CD-ROM drive and start the setup program. (The CD is included in the MA8000/EMA12000 platform kit.)

   The initial screen lists several options, as well as available documentation for the FCSS utility. Refer to this documentation for assistance in running the utility.

2. Choose the option that corresponds to the SAN topology used by your cluster: either the **Fibre Cbannel Hub** (redundant FC-AL) topology or the **Fibre Cbannel Switcb** (redundant Fibre Channel Fabric) topology.

   NOTE: Refer to the *StorageWorks Secure Path for Windows 2000 Installation and Reference Guide* for details on the parameters you must enter to configure Secure Path.

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3. Follow the instructions in the setup program to complete the installation. The installation process copies the drivers into the proper subdirectory and creates the necessary registry entries.
4. Restart the node.
5. Repeat steps 1 through 4 on the other cluster nodes.

Installing the Secure Path Drivers, Secure Path Agent, and Secure Path Manager

This subsection describes how to install the Secure Path drivers and configuration management agent on a cluster node.

NOTE: Perform the steps in this subsection only for the first MA8000/EMA12000 Storage Subsystem in the PDC/O5000. Do not perform these steps for other storage subsystems.

To install the Secure Path Raidisk filter driver, RAIDisk driver, and agent:

1. Insert the Compaq StorageWorks Secure Path Software CD into your CD-ROM drive.
2. If you have CD AUTORUN enabled on your server, the Secure Path setup program will start automatically. Otherwise, choose **Run** from the Start menu and enter the command shown below, substituting your CD-ROM's drive letter in the command shown below.

   drive_letter:\SPINSTAL\SETUP.EXE
3. When the setup starts, choose the **Secure Path Server Install** option. The server option will install the drivers and the agent required by Secure Path.
4. Click **Yes** if prompted to overwrite the existing data.
5. Make sure to enter a validation password. For cluster configurations make sure the password is the same for each member of the cluster.

   NOTE: Be prepared to designate those clients you wish to allow to manage the host. These names have to be fully qualified (for example, "myserver.mydomain.com"). There are many ways to configure TCP/IP on your network. They include a) host files on servers and clients and b) DNS, with NetBios using DNS resolution. Check with your system administrator to ensure proper network configuration.
6. Restart the node.
7. Repeat steps 1 through 6 for every other node in the PDC/O5000.

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To install Secure Path Manager:

1. Insert the StorageWorks Secure Path Software CD in your CD-ROM drive.
2. If you have CD AUTORUN enabled on your server, the Secure Path setup program will start automatically. Otherwise, choose **Run** from the Start menu and enter the command shown below, substituting your CD-ROM's drive letter in the command shown below.

   drive_letter:\SPINSTAL\SETUP.EXE
3. When the setup starts, choose the **Secure Path Client Install** option. This option will install the Secure Path Manager graphical user interface.
4. Repeat steps 1 through 3 for the other nodes in the cluster.

After you install the Secure Path software and before you power on the Storage Hubs, FC-AL Switches, or Fibre Channel SAN Switches, you can install the optional Compaq StorageWorks Large LUN utility. This utility allows cluster nodes to access up to 64 LUNs per target (array controller port).

Specifying the Preferred_Path for Storage Units

You must assign storage units (storagesets) to the array controllers in the storage subsystem to specify which array controller port is used to access particular units at system boot time. The preferred_path unit attribute assigns units to a specific port (1 or 2) on "this_controller" or the "other_controller." In effect, this procedure specifies on which I/O path (array controller port to host bus adapter) the I/O will travel during normal operations.

Initially, it is recommended that you balance the available storagesets between array controller ports in each storage subsystem. As storage demands are defined and individual drive throughput requirements are understood, adjustments to the disk I/O path configuration can be made using the Secure Path Manager.

If you install the Large LUN utility on your PDC/O5000 cluster, a maximum of 256 LUNs can be distributed among the four array controller ports in each storage subsystem. If you do not install the Large LUN utility, a maximum of 16 LUNs can be distributed among the four array controller ports. The 16-LUN restriction is imposed by the Compaq Secure Path software and the MA8000/EMA12000 Storage Subsystems.

IMPORTANT: When offsets are used, always assign LUNs 0-99 to port 1 on each HSG80 Array Controller and assign LUNs 100-199 to port 2.

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If you do not install the optional Large LUN utility on your cluster, there are two accepted methods for distributing LUNs for storagesets:

- You can distribute eight LUNs between the same-numbered ports on both array controllers so that a total of 16 LUNs are assigned across all four controller ports in each storage subsystem. For example, assign LUNs 0 through 3 to array controller A port 1, LUNs 4 through 7 to array controller B port 1, LUNs 100 through 103 to array controller A port 2, and LUNs 104 through 107 to array controller B port 2. If array controller A fails in multibus failover mode, Secure Path automatically gives controller B control over I/O transfers for LUNs 0-3 on port 1 and LUNs 100-103 on port 2.
- You can distribute eight LUNs across all four array controller ports. For example, assign LUNs 0 and 1 to array controller A port 1, LUNS 2 and 3 to array controller A port 2, LUNS 4 and 5 to array controller B port 1, and LUNs 6 and 7 to array controller B port 2. In this configuration, a single controller port can access all eight LUNs in the event of a path failure on the other three ports.

If you do install the optional Large LUN utility on your cluster, then you must follow these guidelines:

- Do not assign unit offsets to any connections.
- Use unit identifiers D0 through D63.
- Distribute the LUNs evenly across all four array controller ports.

To load balance the storagesets between the two array controllers:

1. From the CLI window, enter the following command to obtain a list of all units defined in the storage subsystem:

   ```
   show units
   ```

2. Enter the following command to specify preferred_path for units:

   ```
   set unit# preferred=this_controller
   ```

   or

   ```
   set unit# preferred=other_controller
   ```

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3. Verify that the above changes were made by entering the following command:

   show units full

4. Repeat steps 1 through 3 for each storage subsystem in the PDC/O5000.

You have completed the software configuration required to support your Secure Path environment. Now you are ready to monitor and manage Secure Path activity using the Secure Path Manager.

Powering Up All Other Fibre Channel SAN Switches or Storage Hubs

After installing the Secure Path software, power up all powered-off Fibre Channel SAN Switches or Storage Hubs and restart all nodes in the cluster.

Creating Partitions

Using Disk Management, you must create one extended partition on each logical drive you created previously in the "Configuring a Storageset" section of this chapter. In the Disk Management, logical drives appear as Disk 0, Disk 1, and so on.

Subdivide the extended partition into logical partitions. The first logical partition is a small fraction of the extended partition and is used by Secure Path software to identify the logical drive as an Oracle Parallel Server shared database resource.

Other logical partitions contain the rest of the extended partition capacity and are used for Oracle8*i* Parallel Server shared database resources. One logical partition is required for each Oracle Parallel Server shared database resource.

See the *Oracle8i Parallel Server Setup and Configuration Guide* for information on Oracle8*i* Parallel Server database guidelines and requirements for subdividing the large extended partitions into logical partitions.

To create partitions on a logical drive:

1. Run Disk Management from one node.
2. Create a large extended partition using all of the logical drive space.

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3. Within the extended partition, create a small (50 megabytes) logical partition (for Secure Path) as the first logical partition.

   NOTE: Make the small logical partitions in a storageset different in size by 1 megabyte, for example, 50 megabytes for Disk 0, 51 megabytes for Disk 1, and so on. This provides an easy way to identify the disk. Retain a written record of these small logical partition sizes.

4. To verify that you can write to the shared storage, format the small logical partition with NTFS.

   Drives blink when being formatted. Label the blinking drive with the driver letter assigned to it so it is easily located later.

5. Assign a drive letter and a partition label to the small logical partition. Note the drive letter; the drive letter assignments must be the same on all nodes in the cluster.

6. Using the rest of the space in the extended partition, create logical partitions for shared database resources. Oracle requires unformatted, raw partitions; do not format these logical partitions.

7. Repeat steps 1 through 6 for all logical drives on an MA8000/EMA12000 Storage Subsystem.

8. Restart the node from which Disk Management is running.

9. Run Disk Management from the other nodes and verify that the same logical drives, extended partitions, and logical partitions are seen by all nodes in the cluster. On each node, assign the same drive letters to the small logical partitions that you assigned on the first node.

10. Restart all nodes in the cluster.

11. After all nodes restart, open Disk Management on all nodes and verify that the drive letters are identical from all nodes.

Installing Compaq OSDs

Use the Oracle Universal Installer (OUI) program to install the Compaq operating system dependent modules (OSDs) for Oracle8*i* Parallel Server. Compaq supplies an Oracle8*i* software package with the OUI that installs Compaq OSDs for an Ethernet cluster interconnect.

The OUI runs from one node in the cluster and performs the following tasks:

- Copies the OSDs to the internal hard drive of all cluster nodes.

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- Sets up registry entries for file location and standard registry parameters for the OSDs on all cluster nodes.

From one node in the cluster, the OUI installs and configures OSDs on the other nodes in the cluster, provided that:

- The servers are communicating through a local area network using a TCP/IP protocol.
- The user running the OUI program has administrator privileges on every node.

Verifying Cluster Communications

IMPORTANT: The successful completion of the OUI program depends on TCP/IP connectivity being set up correctly. It also depends on the user running the OUI having administrator access to every node in the cluster. **Before** running the OUI, verify cluster communications and the administrator privileges of the user performing the installation.

If the OSDs do not install successfully, the OUI will not offer the option to install Oracle8*i* Parallel Server Database software.

The Compaq operating system dependent modules (OSDs) are installed from one node in the cluster (the installing node). The node on which you run the OUI program must be able to communicate with every other node in the cluster in order to copy information to all other cluster nodes.

If you have installed an Ethernet cluster interconnect, use the ping utility to verify that each node in the cluster can communicate with every other node. Run the ping utility from each node in the cluster. Ping the client LAN name of every node in the cluster. The client LAN name and client LAN IP address were assigned to each cluster node while you were using SmartStart to install the operating system software.

If you are using an Ethernet cluster interconnect, a cluster interconnect name and IP address were assigned to each cluster node. Ping the Ethernet cluster interconnect name of every node in the cluster.

When using the client LAN name with the ping command, the IP address displayed by the ping utility should be the client LAN IP address. When using an Ethernet cluster interconnect name, the IP address displayed by the ping utility should be an Ethernet cluster interconnect address. If the ping utility does not return the expected IP addresses, check the entries in the hosts and lmhosts files at %SystemRoot%\system32\drivers\etc.

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For example, the command **ping node1** should return the following type of information.

Pinging node1.loc1.yoursite.com [127.0.0.1] with 32 bytes of data:

```
Reply from 127.0.0.1: bytes=32 time<10ms TTL=128
Reply from 127.0.0.1: bytes=32 time<10ms TTL=128
Reply from 127.0.0.1: bytes=32 time<10ms TTL=128
Reply from 127.0.0.1: bytes=32 time<10ms TTL=128
```

Mounting Remote Drives and Verifying Administrator Privileges

Because the OUI installs and configures OSDs on the other nodes in the cluster from the installing machine, you must first mount a drive on all remote nodes in the cluster. Remote nodes are those nodes other than the node on which the OUI is running (the installing machine).

The drive you mount should be the drive the OUI will write to, and it must be the same drive on all cluster nodes. There should be at least five megabytes of space on the remote drives.

The net use command can be used to mount drives on remote nodes. The user running the net use command must have administrator privileges. Therefore, running the net use command not only mounts drives on remote nodes but also verifies the administrator privileges of the installer.

Administrator privileges are required for most installation tasks, such as installing device drivers and changing registry entries. To install the OSDs, the user must have administrator privileges on each node from the installing machine.

To mount drives on remote nodes, enter a net use command from a C: prompt on the installing machine. Enter one instance of the command for each remote cluster node. The following example mounts the C: drive on a remote node:

```
C: net use \\machine_name\C$ * /User: <admin_login >
```

The "*" results in the system prompting you for a password, and the password is not echoed. (The Map Network Drive option in Windows Explorer is an alternative to the net use command.)

If successful, the net use command returns:

```
"The command completed successfully."
```

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If the command is not successful, make sure the administrative shares on remote node drives are present.

Installing the Ethernet OSDs

To install the OSDs for an Ethernet cluster interconnect:

1. From the installing node, log in as a user who has administrator privileges on all nodes in the cluster. If all servers in the cluster are in the same domain, log in as a user who is a member of the Domain Administrators group. If the servers are in different domains, create a local user on each server with the same Windows Server user name and password on each node. Then make that local user a member of the local Administrators group on each node before installing the OSDs.
2. Insert the Compaq Parallel Database Cluster Clustering Software for Oracle8*i* on Microsoft Windows 2000 CD into the CD-ROM drive.
3. If autorun is enabled, the Oracle Universal Installer **Welcome** screen appears.

   If autorun is disabled, enter ***d*:\setup** at a C: prompt. Substitute the letter assigned to the CD drive for ***d***. The Oracle Universal Installer **Welcome** screen appears.

   NOTE: The **OUI** screens presented here might indicate earlier revision levels for the OSDs.

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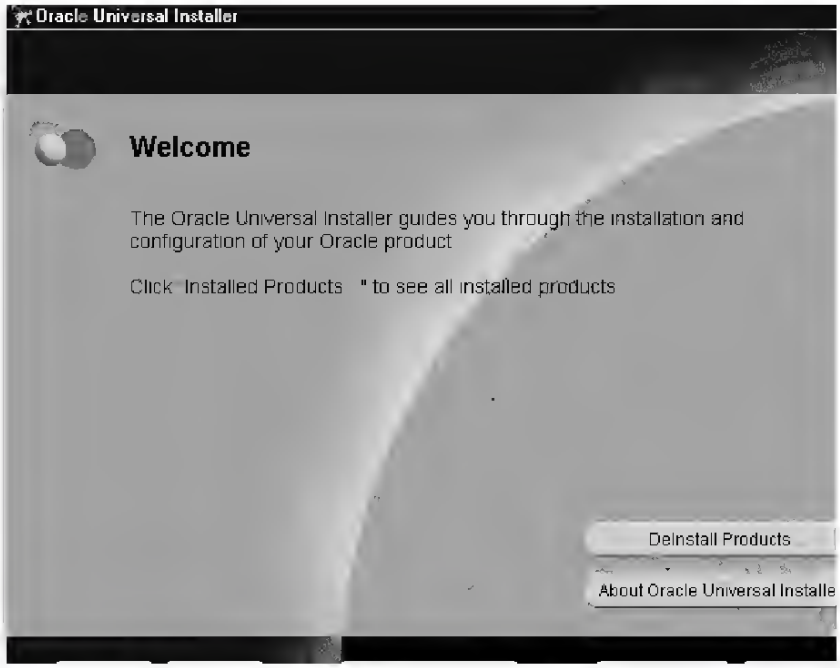
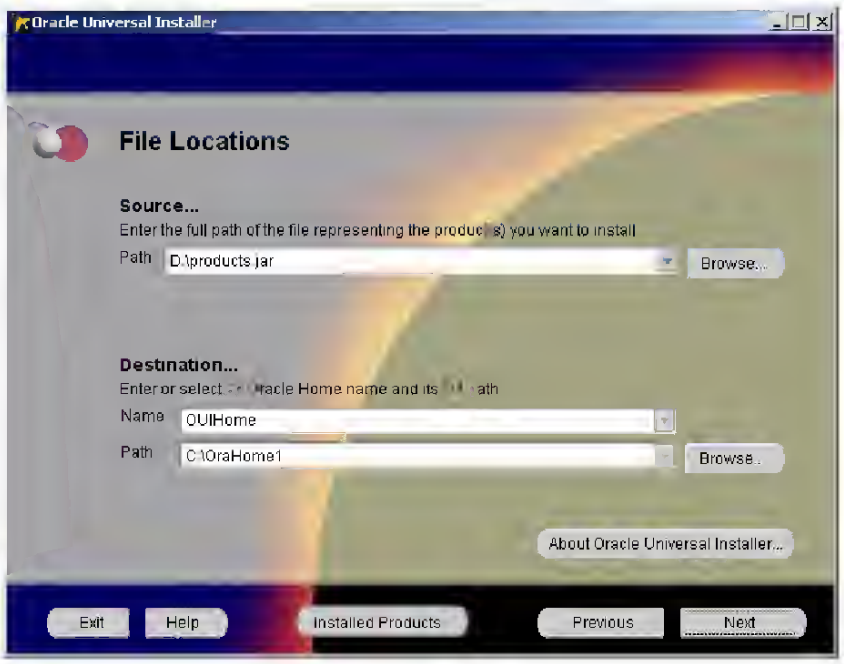

Oracle Universal Installer
Welcome
The Oracle Universal Installer guides you through the installation and configuration of your Oracle product
Click " Installed Products " to see all installed products
Deinstall Products
About Oracle Universal Installe

4. Click **Next** to continue. The **License** screen appears.
5. Click **Accept** to accept the terms of the license agreement. The **File Locations** screen appears.



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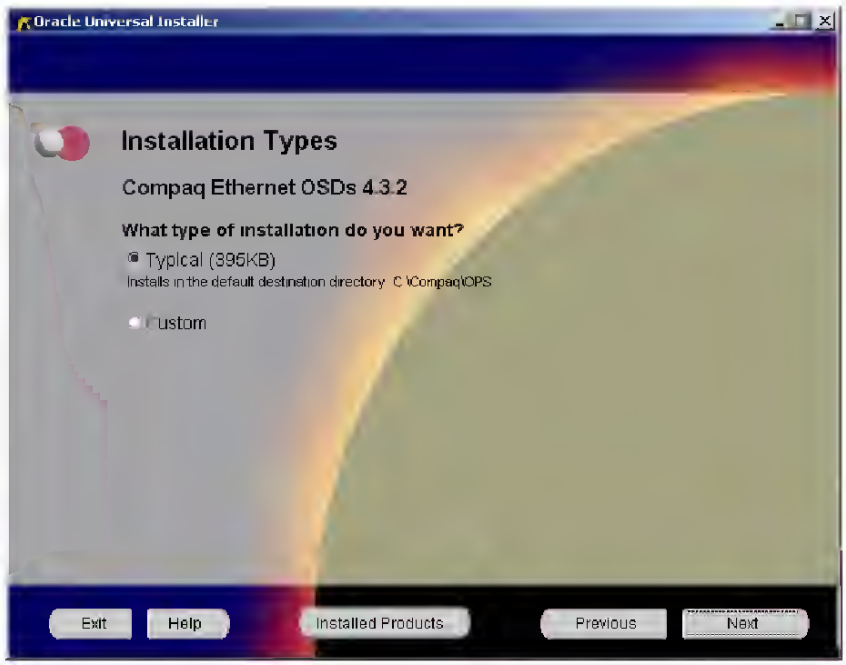
6. Click **Next** to continue. The **Installation Types** screen appears.



7. Select **Typical** to install the Ethernet OSDs into the default location, C:\Compaq\OPS. Skip to step 12.

8. Select **Custom** to install the Ethernet OSDs into a location of your choice. The **Component Locations** screen appears.

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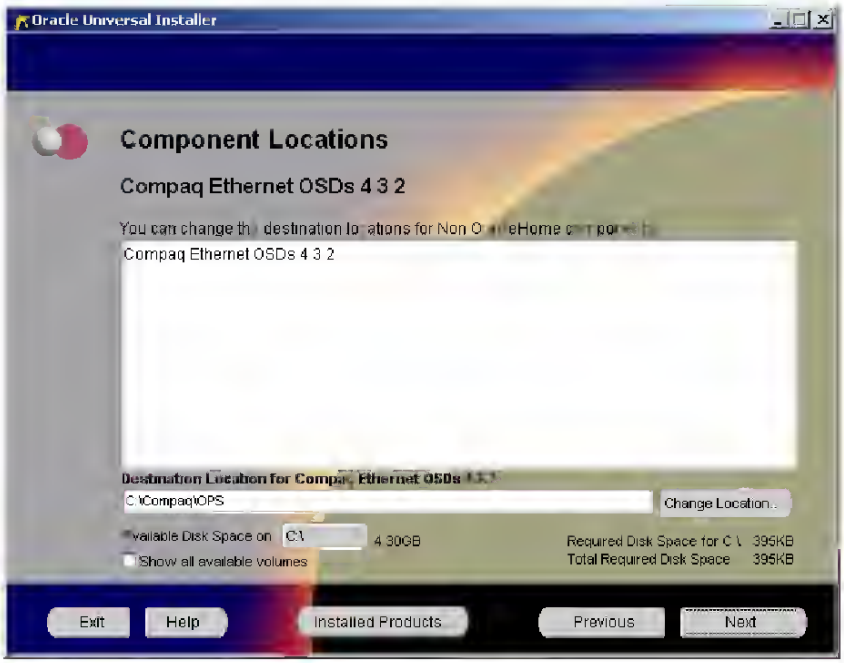

9. If you want to accept the default location, skip to step 13.

10. If you want to specify an alternate location and you know the exact directory path, specify it by typing over the default location and skip to step 12.

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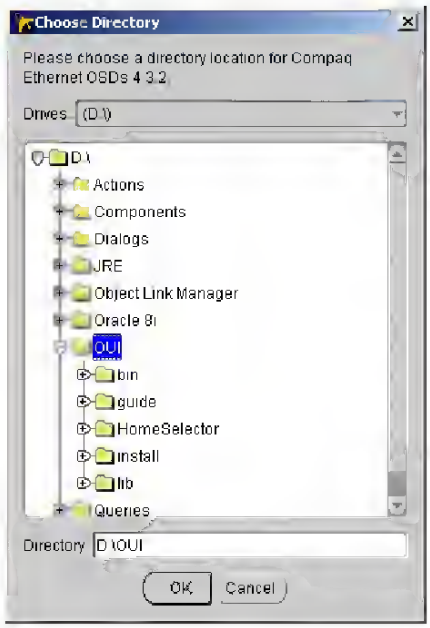
11. If you want to specify an alternate location but do not know the exact directory path, click **Change Location.** The **Choose Directory** screen appears.



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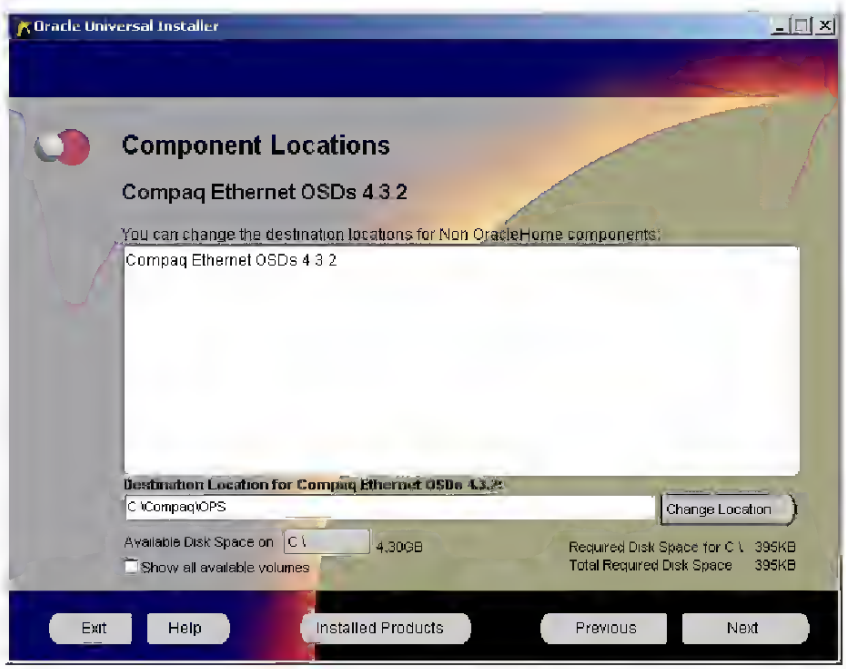
12. Browse to the location where you want to install the OSDs. Click **OK.** The **Component Locations** screen appears indicating the alternate location you specified.



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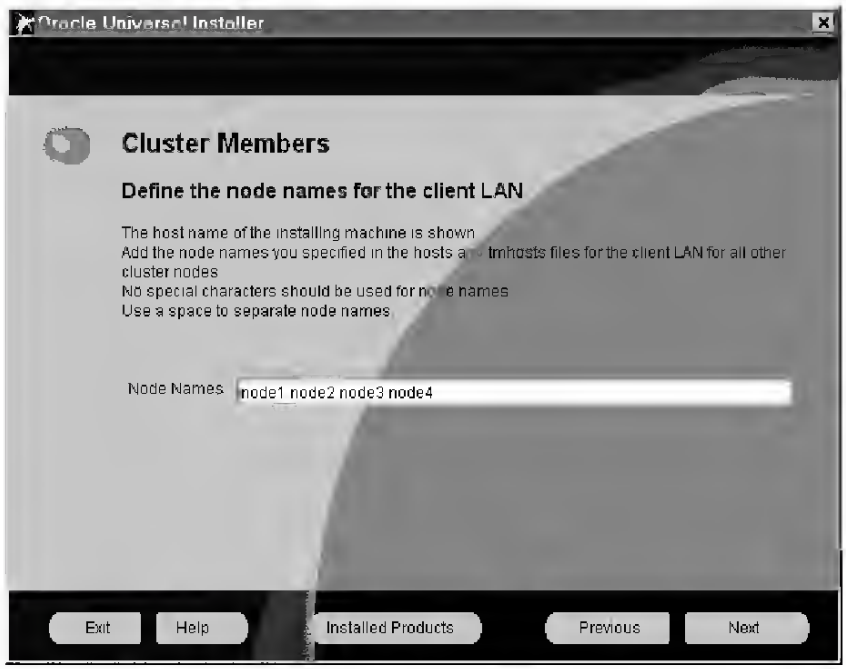
13. Click **Next** to continue. The **Cluster Members** screen appears.


Oracle Universal Installer
Cluster Members
Define the node names for the client LAN
The host name of the installing machine is shown
Add the node names you specified in the hosts and lmhosts files for the client LAN for all other cluster nodes
No special characters should be used for node names
Use a space to separate node names
Node Names
node1 node2 node3 node4
Exit
Help
Installed Products
Previous
Next

14. The **Cluster Members** screen indicates the host name of the installing machine. Define the node names for the client LAN by adding the node names you specified in the hosts and lmhosts files for the client LAN for all other cluster nodes. Do not use special characters. Use a space to separate the node names.

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15. Click **Next** to continue. The **Cluster Members** screen reappears.

Oracle Universal Installer
Cluster Members
Define node names for the cluster interconnect
The client LAN node names you specified are shown with _san' appended to each
If necessary retype the node names to match the names you specified in the hosts and
lmhosts files for the cluster interconnect
No special characters should be used for node names
Use a space to separate node names
Node names
node1_san node2_san node3_san node4_san
Exit
Help
Installed Products...
Previous
Next

16. The **Cluster Members** screen now shows the node names you specified on the first **Cluster Members** screen with "_san" appended to each name, indicating it as a cluster interconnect node name.

    If necessary, retype the cluster interconnect node names to match the names you entered into the hosts and lmhosts files for the Ethernet cluster interconnect. Do not use special characters. Separate the node names with a space.

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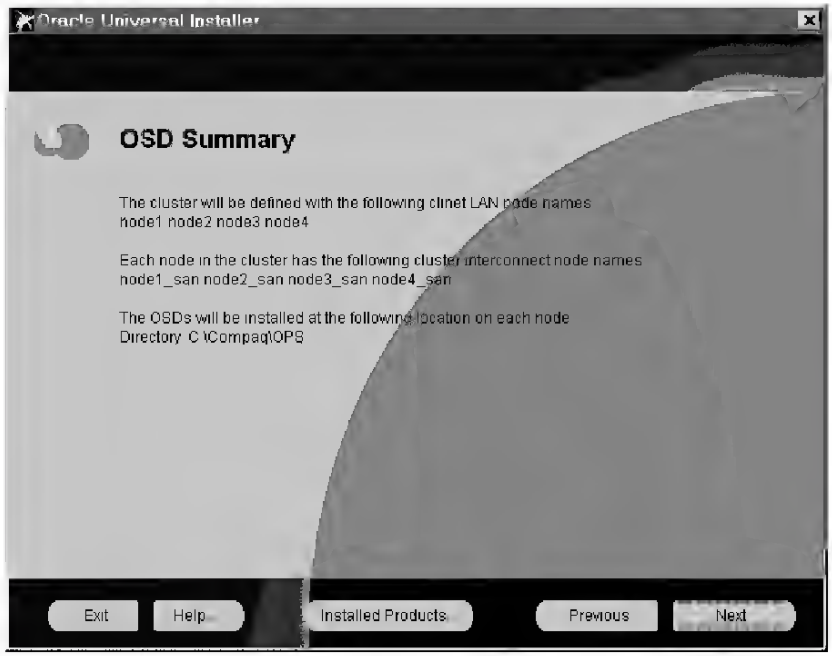
17. Click **Next** to continue. The **OSD Summary** screen appears.


Oracle Universal Installer
OSD Summary
The cluster will be defined with the following clinet LAN node names
node1 node2 node3 node4
Each node in the cluster has the following cluster interconnect node names
node1_san node2_san node3_san node4_san
The OSDs will be installed at the following location on each node
Directory C:\Compaq\OPS
Exit
Help
Installed Products
Previous
Next

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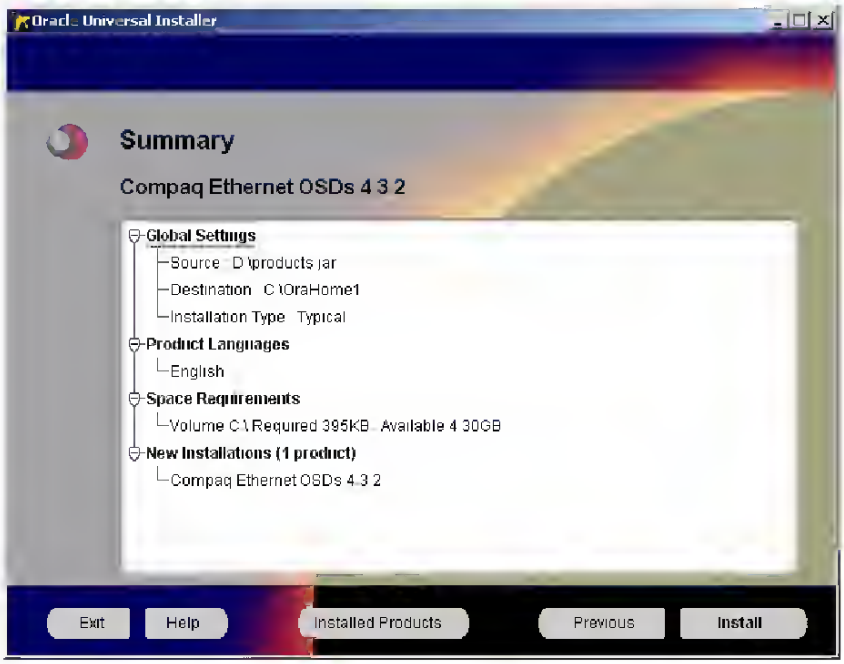
18. If the information on the **OSD Summary** screen is not correct, click **Previous** to modify the previous screens.

    When the information is correct, click **Next** to continue. The **Summary** screen appears.



19. Click **Install** to install the components listed in the summary. At this point, the OUI verifies that the installing node can communicate with other cluster nodes through both the client LAN and cluster interconnect node names. If the OUI cannot communicate with all nodes, this process can take awhile. If the node is not accessible, an error message will appear asking you to check the hostname and the network connection.

20. An **Install** screen appears that shows a percentage completion bar as the installation progresses.

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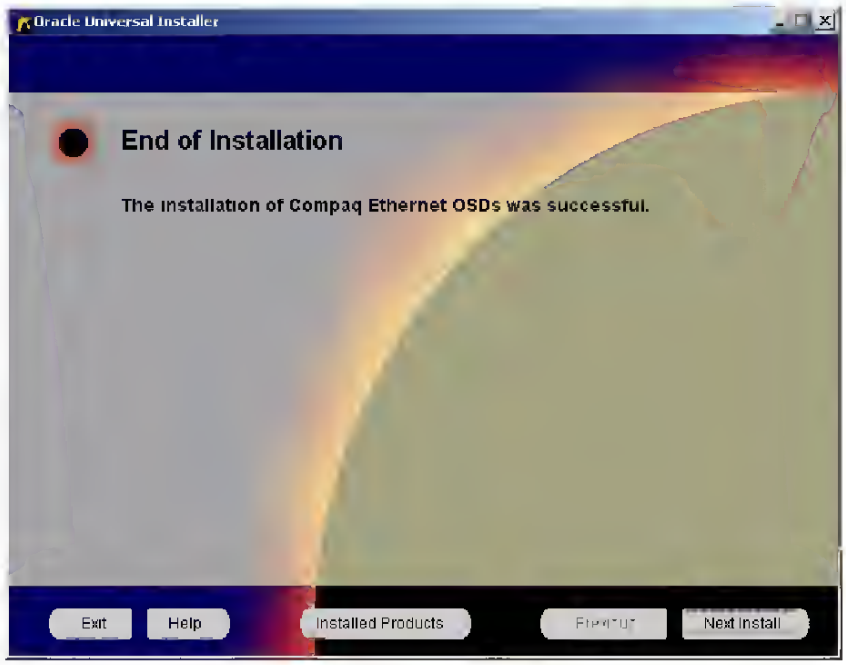
21. When the installation completes, the **End of Installation** screen appears.



22. Click **Exit** to quit the OUI or **Next Install** to install another product.

23. Start the cluster manager, **OracleCMService,** on all nodes in the cluster. This service must be started before installing Oracle software. See the Oracle documentation for information on starting the cluster manager.

Installing Oracle Software

Using the *Oracle8i Parallel Server Setup and Configuration Guide*, follow the steps to install Oracle8*i* Enterprise Edition software on all cluster nodes, including:

- Oracle8*i* Server
- Oracle8*i* Parallel Server Option

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- Oracle8*i* Parallel Server Manager
- Oracle8*i* Enterprise Manager

NOTE: If the Oracle Universal Installer does not offer the option to install Oracle8*i* Parallel Server, it could mean that the OSDs did not install successfully or that the OracleCMService is not running.

After installing Oracle software, the Oracle manual instructs you to install vendor-supplied operating system dependent modules (OSDs). You have already completed this step.

Configuring Oracle8*i* Software

Configuring Oracle software includes configuring Oracle8*i* Parallel Server, Oracle8*i* Parallel Server Manager, Oracle8*i* Enterprise Manager, and administering multiple instances. Use the *Oracle8i Parallel Server Setup and Configuration Guide* and the *Oracle8i Enterprise Edition for Windows 2000* to configure the Oracle8*i* software.

Installing Object Link Manager

IMPORTANT: Before installing and configuring an Oracle database, you must install Object Link Manager on all cluster nodes. Object Link Manager maintains the symbolic links between disk partitions and Oracle data files. Failure to install Object Link Manager can result in the Oracle database not starting or, if it starts, in not finding the correct data.

Windows 2000 Advanced Server assigns disk numbers to drives in the shared storage subsystems based on the order in which the shared storage subsystems are powered on.

The order in which disks are brought online directly affects the disk numbers assigned to the disk, which in turn affects the ability of Oracle8*i* Server to find Oracle data files. If shared storage subsystems are powered off and then powered on in a different order than they were when the cluster was initially configured, the order and numbering of the shared disk drives will change for all nodes in the cluster.

Object Link Manager simplifies the creation and maintenance of symbolic links between disk partitions and Oracle data files by placing the symbolic link names directly into the disk partitions, thereby tracking the symbolic links dynamically. This means that if the order in which disk drives are brought

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online changes, Oracle8*i* Server can find the correct data files and can properly start the Oracle database.

You must install Object Link Manager before installing the Oracle database software to ensure that the symbolic links are defined before creating a database.

For instructions on installing and using Object Link Manager, see the readme file on the Compaq Parallel Database Cluster Clustering Software for Oracle8*i* on Microsoft Windows 2000 CD at

\Object Link Manager\readme.txt

Additional Notes on Configuring Oracle Software

In addition to the steps outlined in the Oracle documents, you must create a symbolic link for OPS_CMDISK. You should verify access to the shared storage from all nodes of the cluster.

Creating a Symbolic Link for OPS_CMDISK

The OPS_CMDISK data file contains status information for all nodes in the cluster. Using the Object Link Manager GUI, define a partition to be called OPS_CMDISK and commit the change.

Verifying Access to Shared Storage from All Nodes

IMPORTANT: Verify access to shared storage from all nodes in the cluster **before** starting any Oracle instance.

Open Disk Management to verify that the shared disk resources are seen from this node as they are seen from other installed nodes in the cluster.

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Verifying the Hardware and Software Installation

Cluster Communications

Use the ping utility to verify that each node in the cluster can communicate with every other node over the client LAN. Run the ping utility from the installing cluster node. Verify the installing node can communicate with all cluster nodes by pinging the client LAN name. The IP address displayed by the ping utility should be the client LAN IP address.

If you are using an Ethernet cluster interconnect, ping the Ethernet cluster interconnect name. The IP address displayed by the ping utility should be the Ethernet cluster interconnect address. If this is not the case, check the entries in the hosts and lmhosts files at %SystemRoot%\system32\drivers\etc.

Access to Shared Storage from All Nodes

Use Disk Management to verify that the same shared disk resources are seen from this node as they are from other installed nodes in the cluster.

OSDs

After verifying all the nodes have access to the shared storage, start an Oracle instance. For example, at a C: command prompt start an instance by entering:

```
net start oracleservice<SID>
```

If the OSDs are installed correctly, a message will appear indicating that the Oracle service has started successfully.

If the Oracle service did not start successfully, make sure that the OracleCMService is started and the SID is in the Oracle registry. There are two logs that can provide information about why the Oracle service did not start. These logs are:

- \Compaq\OPS\cmsrvr.log
- \Compaq\OPS\nm.log

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Other Verification Tasks

Perform these other verification tasks:

- Verify that Object Link Manager has been installed and is running.
- Verify that the OPS_CMDISK symbolic link has actually been set.

To verify that the Object Link Manager has been installed and is running, go to the **Services** screen. From there, look for "Oracle Object Service" in the list of services and see if it is shown as "Started".

To verify that the OPS_CMDISK symbolic link has been set:

- If the Object Link Manager service is running, run the Object Link Manager to see if the link OPS_CMDISK is in the list of links.

Power Distribution and Power Sequencing Guidelines

Overview

It is recommended that you connect most cluster components to a Compaq power distribution unit (PDU). PDUs connect to an uninterruptible power source (UPS) or building power. The power distribution units and UPSs are the only cluster components connected to a building power source. If there is no UPS, the PDU plugs into building power.

It is also recommended that you connect cluster components, such as servers, storage subsystems, switches, and hubs to two PDUs and UPSs so the cluster components continue to operate if one PDU or UPS fails.

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Server Power Distribution

Figure 5-8 shows an example of server power distribution for a three-node cluster. Power supply #1 of each server is connected to PDU #1. Power supply #2 of each server is connected to PDU #2.

PDU #1 is connected to UPS #1, and PDU #2 is connected to UPS #2. Each UPS is connected to building power.

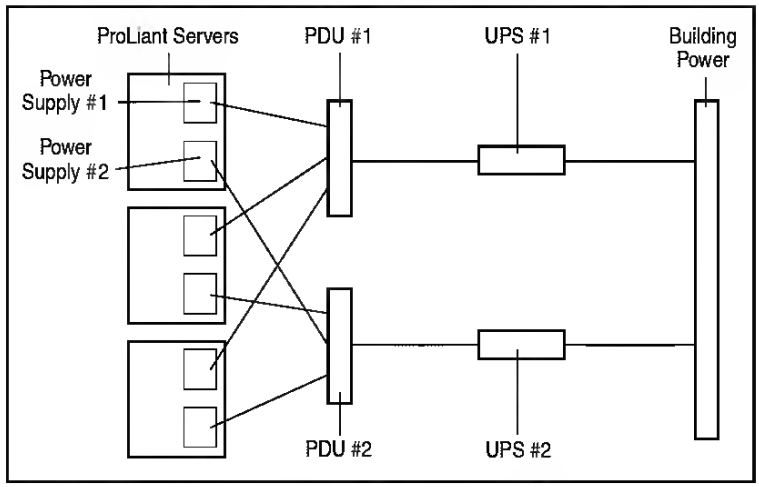

Figure 5-8. Server power distribution in a three-node cluster

Having two PDUs and UPSs in the cluster provides two paths from the servers to building power and means that the cluster stays up and running if a PDU or UPS fails in one of the paths.

Storage Subsystem Power Distribution

The power distribution for storage subsystem enclosures, with respect to connecting them to PDUs and UPSs, can be configured similarly to the example shown for server power distribution.

Each enclosure in an MA8000/EMA12000 Storage Subsystem has two AC power inlets. Substituting power inlets for power supplies and storage subsystem enclosures for ProLiant servers shown in Figure 5-8, you can provide two redundant paths from the storage subsystem enclosures to building power.

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Power Sequencing

The following power sequencing information applies to existing clusters that are up and running. The cluster installation steps presented previously in this chapter might have instructed you to perform a different sequence.

Be sure to power down the cluster components in the following order:

1. ProLiant servers
2. Ethernet switches
3. MA8000/EMA12000 Storage Subsystem controller enclosure
4. MA8000/EMA12000 Storage Subsystem disk drive enclosures
5. Fibre Channel SAN Switches or Storage Hubs (Power is applied to the Storage Hub when the AC power cord is plugged in.)

Shutting down and powering off the servers first allows them to perform tasks such as flushing queued database write transactions to disk and properly terminating running processes.

Be sure to power up the cluster components in the following order:

1. Fibre Channel SAN Switches or Storage Hubs (Power is applied to the Storage Hub when the AC power cord is plugged in.)
2. MA8000/EMA12000 Storage Subsystem disk enclosures
3. MA8000/EMA12000 Storage Subsystem controller enclosure
4. Ethernet switches
5. ProLiant servers

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Chapter 6

Cluster Management

Throughout the life of your cluster, you might need to improve its performance, upgrade hardware components, upgrade software, increase storage capacity, and monitor ongoing activities. This chapter describes these management activities for the Compaq Parallel Database Cluster Model PDC/O5000 (referred to here as the PDC/O5000). The topics addressed in this chapter include:

- Cluster management concepts
- Management applications
- Software maintenance
- Managing changes to shared storage
- Replacing a cluster node
- Adding a cluster node
- Managing cluster operation

NOTE: The procedures in this chapter contain high-level instructions. The instructions summarize what has either already been discussed in this guide, Oracle documentation, or storage subsystem documentation.

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Cluster Management Concepts

Powering Off a Node Without Interrupting Cluster Services

At some time during the life of your cluster you will need to perform an operation on a cluster node that will require it to be powered off. Physically moving the cluster node, removing a hardware device, and adding a hardware device commonly require the node to be powered off.

It is a good practice to gracefully shut down the node before powering it off. The process of gracefully shutting down a node in a PDC/O5000 can be summarized as:

1. Make sure that clients connecting to the database through the node can reconnect to the database through one of the other nodes.
2. Properly shut down the Oracle instance running on the node.
3. Shut down the server.

The node can now be powered off safely. The database will remain accessible since the remaining cluster nodes are operating normally.

Managing a Cluster in a Degraded Condition

Due to the high availability benefits of clustering, applications and network clients remain operational even while some cluster components do not. When the cluster enters a degraded condition, it is helpful to follow this troubleshooting process:

1. Determine what caused the degradation.
2. Determine whether the condition affects one cluster node, multiple cluster nodes, or all cluster nodes.

   If one or more nodes is unaffected by the condition, and if enough performance can be obtained from the unaffected nodes, continue operating the database.
3. Determine whether the condition will continue to worsen.

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4. Determine how critical it is to repair the problem.

   a. If the problem is not considered to be critical, wait until a non-peak time to service the problem.

   b. If the problem is critical but does not affect all cluster nodes, shut down the Oracle instances on the affected nodes and wait until a non-peak time to service the problem.

   c. If the problem is critical and affects all the cluster nodes, shut down the database instances on all cluster nodes and correct the problem.

Managing Network Clients Connected to a Cluster

An important aspect of managing network clients is informing users that their applications are now running on a cluster. As the cluster is initially brought into production, it can be helpful to describe in a memorandum the effects a cluster will have on user ability to access the database.

Since users will experience some disruption of service and possibly performance degradation during a node eviction, they might become concerned about the availability and stability of their applications.

When a node eviction or node integration occurs, the users will notice that for a brief moment they cannot access their database. When users have been properly forewarned of the effects of operating in a clustered environment, they will more readily recognize when such an event is occurring. Most users will then know to wait several seconds before attempting to reaccess their database.

Cluster Events

The majority of cluster events can be viewed either within the Event Log or within specific error log files. Oracle8*i* Server events are sent to the Application Event Log and can be viewed from Event Viewer.

The lower-level software components, such as the cluster manager, send events to error log files.

NOTE: If the OSDs are not installed in the default directory, the log files will be in the same directory as the OSDs.

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The following log files are used:

- The Node Manager (NM), provided by Compaq, logs messages to C:\compaq\ops\nm.log
- By default, the OracleCMService sends messages to C:\compaq\ops\cmsrvr.log

Management Applications

Monitoring Server and Network Hardware

Compaq Insight Manager is used to manage the hardware components of your cluster. Compaq Insight Manager, loaded from the Compaq Management CD, is an easy-to-use software utility for collecting server, storage, and network information. Compaq Insight Manager performs the following functions:

- Monitors fault conditions and system status
- Monitors shared storage and interconnect adapters
- Forwards server alert fault conditions
- Remotely controls servers

In Compaq servers, each hardware subsystem, such as network adapters, system processors, and system memory, has a robust set of management capabilities. Compaq Full Spectrum Fault Management notifies of impending fault conditions.

Several steps are required to configure the system for Compaq Insight Manager. For example you must:

- Load Insight agents on each cluster node.
- Install the Compaq Insight Manager Console.
- Make sure that proper user rights are granted.

For additional information concerning Compaq Insight Manager, see the Compaq Server Setup and Management pack.

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Compaq Insight Manager XE is a web-based management system that can also be used to monitor cluster hardware components. Compaq Insight Manager XE is an optional CD available upon request from the Compaq System Management website at

www.compaq.com/sysmanage

Monitoring Storage Subsystem Hardware

StorageWorks Command Console (SWCC) is used to monitor the storage subsystem hardware components of your cluster. The SWCC is a graphical user interface that can be used as an alternative to the Command Line Interface for monitoring and managing a MA8000/EMA12000 Storage Subsystem.

Managing Shared Storage

There are two levels of management with shared drives. The physical disks and the drive arrays created from them are managed with MA8000/EMA12000 utilities. The logical drives are created and managed with Disk Management.

The PDC/O5000 manages the shared disks with the graphical StorageWorks Command Console and with the Command Line Interface (CLI). The multipath component of the shared storage subsystems is managed with Secure Path Manager.

Using the Command Line Interface

The Command Line Interface (CLI) enables comprehensive, precise control over the MA8000/EMA12000 Storage Subsystem. The CLI supports dozens of commands to configure, modify, and diagnose problems in the storage subsystem. For example, the CLI enables you to configure the failover setting of the array controllers, set the RAID levels of the drives, and view the connections between the servers and the storage subsystem.

For detailed information, see the Compaq StorageWorks documentation.

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Using the Compaq StorageWorks Command Console

The StorageWorks Command Console (SWCC) is a graphical user interface used to create and manage storage subsystems for the PDC/O5000. While the CLI window provides very detailed control over the storage subsystem, the StorageWorks Command Console replicates most of the CLI window functions in a graphic form and provides a user-friendly method of executing CLI commands.

See the StorageWorks documentation for details about using the SWCC.

Using Secure Path Manager

The primary use of the CLI and the SWCC is to manage shared disks and array controllers. Secure Path Manager is used to manage the redundant paths of the shared storage system.

Secure Path Manager is a component of the Compaq StorageWorks Secure Path software that is included in the PDC/O5000 cluster kit. Secure Path Manager is the client application used to manage multipath MA8000/EMA12000 Storage Subsystem configurations. It displays a graphical representation of the current multipath environment and indicates the location and state of all configured storagesets on each of the paths. To facilitate static load balancing, Secure Path Manager provides the capability to move storagesets between I/O paths.

For detailed information, see the Secure Path documentation provided with the Secure Path CD.

Using Disk Management

The Disk Management utility is first run after the drive arrays have been configured by the MA8000/EMA12000 utilities. Disk Management is used to partition the drive arrays, create logical drives, assign drive letters, and format the logical drives. For additional information about Disk Management, refer to your Windows 2000 documentation.

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Monitoring the Database

Oracle8*i* Enterprise Manager uses agents to continuously monitor database activities and offers a graphical console allowing administrators to manage the database. From the Enterprise Manager Console, the administrator can administer, diagnose, and tune multiple databases. Jobs can also be scheduled, software can be distributed, and objects and events can be monitored from the console.

Several steps are required to properly configure the system for Oracle8*i* Enterprise Manager. Additional steps are required to integrate the management of parallel databases. For example, you must do the following:

- Create an Enterprise Manager Repository on the console node.
- Obtain sufficient rights on the console machine as well as on the managed cluster nodes.
- Install Oracle agents on each managed node.

Refer to the Oracle8*i* documentation, including:

- *Oracle Enterprise Manager Administrator's Guide*
- *Oracle Enterprise Manager Configuration Guide*
- *Oracle Enterprise Manager Concepts Guide*
- *Oracle8i Parallel Server Setup and Configuration Guide*
- *Oracle8i Parallel Server Concepts*
- *Oracle8i Parallel Server Administration, Deployment, and Performance*

Oracle8*i* Enterprise Manager and its corresponding documentation are shipped as part of Oracle8*i* Enterprise Edition.

Remotely Managing a Cluster

Oracle8*i* Enterprise Manager, Compaq Insight Manager, and Compaq Insight Manager XE can be run from any network client machine that has network access to the cluster nodes. They can operate on Windows NT Server, Windows 95, or Windows 2000.

Before installing Compaq Insight Manager, Compaq Insight Manager XE, or Oracle8*i* Enterprise Manager, it is recommended that you read through the corresponding documentation to determine how to set up and configure each of these programs to run remotely.

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Software Maintenance

Deinstalling the OSDs

At some point, you might want to deinstall the operating system dependent modules (OSDs). Some example situations are:

- When a node is being permanently removed from the cluster
- When a node is being replaced
- When a node is being added to the cluster
- When the OSDs are being upgraded to a newer revision level

Use Oracle Universal Installer to deinstall the OSDs.

IMPORTANT: The Oracle Universal Installer removes the OSDs from all cluster nodes. To properly maintain the cluster, the Oracle Universal Installer cannot remove the OSDs from individual nodes. After the OSDs are deinstalled, the cluster is disbanded and cannot run until the OSDs are reinstalled on all the nodes.

Be sure to shut down the Oracle instance on all nodes and stop the Oracle services running on all nodes prior to removing the OSDs.

To deinstall the OSDs:

1. Log in as a user who has administrator privileges on all nodes in the cluster.
2. Insert the Compaq Parallel Database Cluster Clustering Software for Oracle8*i* on Microsoft Windows 2000 CD into the CD-ROM drive of the primary node. This is the node where the OSDs were installed originally.

IMPORTANT: To deinstall the OSDs, you must run the Oracle Universal Installer from the same node where the OSDs were installed.

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3. If autorun is enabled, the Oracle Universal Installer **Welcome** screen appears.

4. If autorun is disabled, enter ***d*:\setup** at a C: prompt. Substitute the letter assigned to the CD drive for ***d***. The Oracle Universal Installer **Welcome** screen appears.

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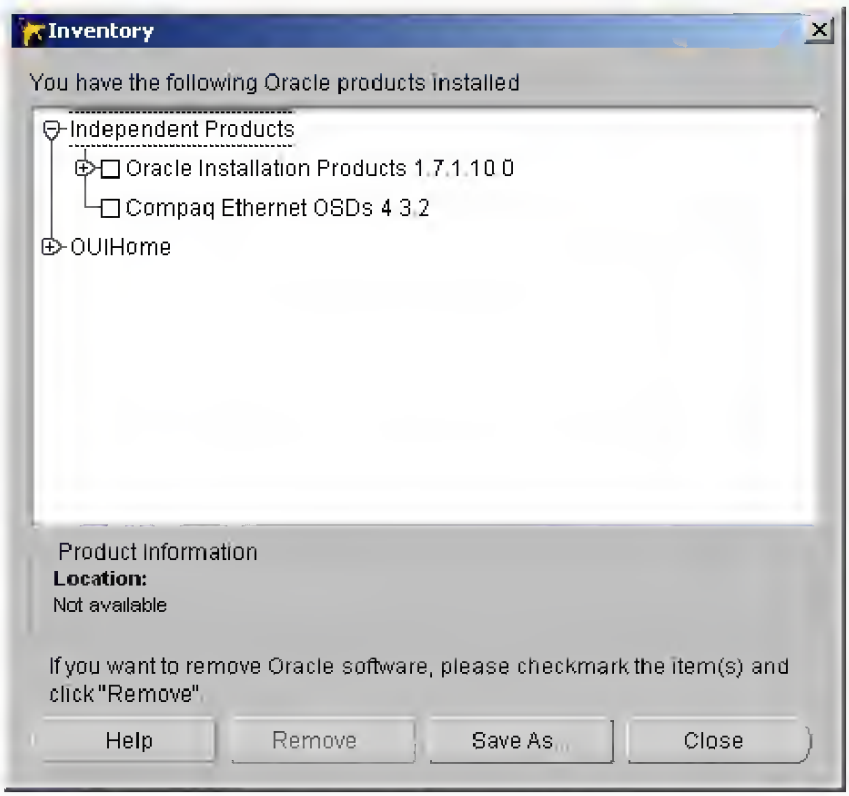
5. Click **Deinstall Products.** Next, a window containing an inventory of the installed components appears. The following shows the **Inventory** screen that is displayed with an Ethernet cluster interconnect.



6. Checkmark **Compaq Ethernet OSDs** and click **Remove.**

NOTE: Your screen might indicate later revision levels for the OSDs.

7. Follow the Oracle Universal Installer directions to complete the deinstallation.

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Upgrading Oracle8*i* Server

The design of the PDC/O5000 is tightly integrated with Oracle8*i* Server. Significant changes in Oracle8*i* Server will likely affect the operation of the cluster.

Before upgrading to any new release of Oracle8*i* Server, consult your Compaq and Oracle service representatives. Make sure that the new release is certified and supported on the PDC/O5000, and get assistance to determine which procedure you should follow to perform the upgrade properly.

Upgrading the OSDs

During the life of your PDC/O5000, you will need to upgrade the operating system dependent modules as new versions are released.

Before beginning the upgrade procedure:

1. Make sure that the person performing the upgrade has administrative privilege on each cluster node.
2. Make sure that all cluster nodes are active. From each node, run the ping utility to verify that every node recognizes the other nodes by host name.
3. Shut down the Oracle database on all nodes.
4. Stop the Oracle services (OracleCMService, OracleNMService, and OracleService*SID*) on all nodes.

Once you have completed these steps, you can deinstall the existing OSDs and install the new versions as described in the following subsections.

Upgrading the Ethernet OSDs

To upgrade the Ethernet OSDs:

1. Insert the CD containing the new revision of the OSDs into the CD-ROM drive on the primary node. (This is the node that was used for the previous installation of the OSDs.)

   The **Oracle Universal Installer** window is displayed.

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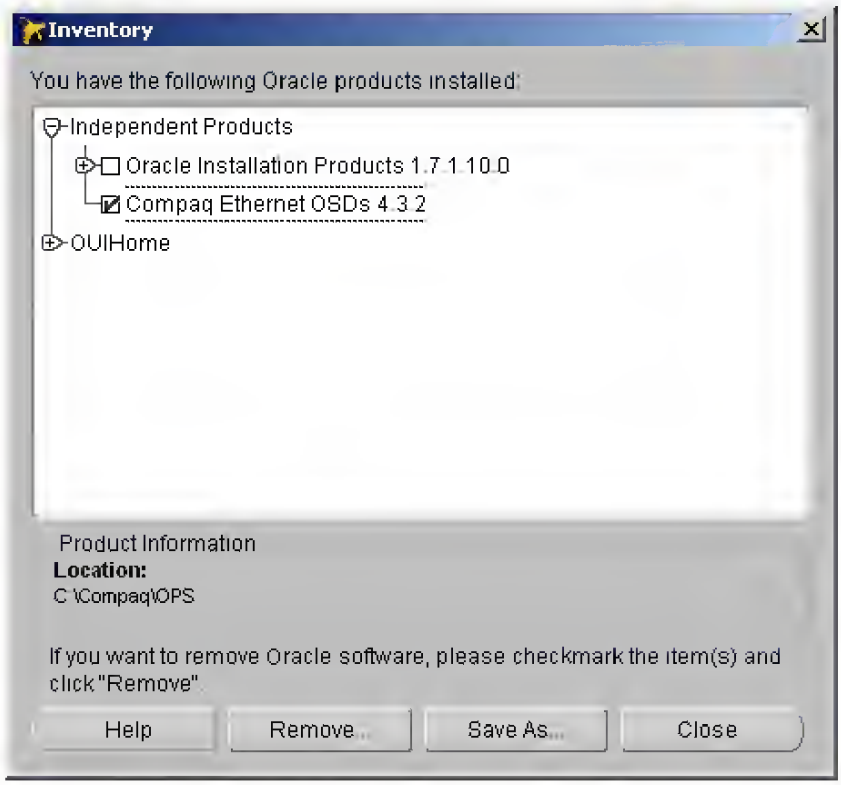
2. Click **Deinstall Products.** The **Inventory** screen showing a list of installed components is displayed:



3. Checkmark **Compaq Ethernet OSDs** and click **Remove.**

   The Oracle Universal Installer removes all Ethernet OSDs.

4. After the deinstallation has finished, restart all nodes.

5. Install the new Ethernet OSDs from the new by following the procedure described under "Installing Compaq OSDs" in Chapter 5, "Installation and Configuration."

6. After installing the new Ethernet OSDs, restart OracleCMService and OracleNMService on all nodes.

7. Restart the Oracle instances on all nodes.

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Deinstalling a Partial OSD Installation

While not a common occurrence, the Oracle Universal Installer might not be able to complete the installation of the Compaq Ethernet OSDs. An incomplete OSD installation could occur for a variety of reasons, for example:

- A cable is no longer seated tightly into its connector.
- The node from which you are running the Oracle Universal Installer cannot communicate with all other nodes in the cluster.
- The user running the Oracle Universal Installer does not have administrator privileges on all cluster nodes.

An incomplete installation can result in a partial installation of the OSDs on the cluster. If this occurs, you must clean up after the partial installation (by removing it) before you can successfully run the Oracle Universal Installer again.

To remove a partial OSD installation:

1. Insert the Compaq Parallel Database Cluster Clustering Software for Oracle8*i* on Microsoft Windows 2000 CD into the CD-ROM drive of a cluster node.
2. From a command prompt, navigate to the CD-ROM drive.
3. Connect to the **\Utilities** directory.
4. Run the uninstall utility by entering:

   uninstallOSD

5. Restart the node.
6. Repeat steps 1 through 5 on every node in the PDC/O5000 cluster.

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Managing Changes to Shared Storage Components

Adding New Storagesets to Increase Shared Storage Capacity

During the life of your PDC/O5000, you might need to expand the capacity of your shared storage subsystem. The following steps describe how to add a storageset to the MA8000/EMA12000 Storage Subsystem and how to allocate it to Oracle.

IMPORTANT: This activity requires restarting the cluster nodes, so it is recommended you perform these steps during non-peak hours.

To add new storagesets to a Secure Path configuration:

1. Physically add the disks to the MA8000/EMA12000 disk enclosures.
2. Use the HSG80 Storage window, located within the StorageWorks Command Console (SWCC) program, to create new storagesets on the storage subsystem.
3. To configure a new storageset unit, verify access to it, and create partitions for it, follow the procedures in these subsections:
   - "Configuring a Storageset" in Chapter 5, "Installation and Configuration."
   - "Creating Partitions" in Chapter 5, "Installation and Configuration."
4. Use the CLI window to specify a storage unit I/O path for the new unit.
5. Restart all cluster nodes so the Secure Path software can configure the new unit.
6. Run Secure Path on one cluster node. This enables Secure Path to recognize the newly-added logical drive volumes and partitions.
7. Perform the necessary Oracle commands to associate the new data files to the database. See the Oracle setup and configuration documentation provided with the Oracle software for detailed instructions.

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Expanding a Logical drive Within a Storageset

Expanding the size of a logical drive within a storageset is a complex process and should be attempted only by the site database administrator.

The major steps in expanding a logical drive within a storageset are:

1. Back up the database.
2. Shut down the Oracle instance on each cluster node.
3. Delete the extended partition on the logical drive to be expanded.
4. Recreate the logical drive with the added capacity.
5. Perform the steps in the following subsections for the recreated logical drive.
   - "Configuring a Storageset" in Chapter 5, "Installation and Configuration."
   - "Creating Partitions" in Chapter 5, "Installation and Configuration."
6. Restore the database.

Replacing a Failed Drive in a Storage Subsystem

At some point, you might need to replace a failed drive in an MA8000/EMA12000 Storage Subsystem. It is assumed you are using RAID levels 1, 0+1, 3/5, or 5 for all devices in the storage subsystem. When a disk drive fails in a RAIDset or mirrorset, the array controller automatically places it into the failed set and reduces the storageset so that it can operate without one of its members.

IMPORTANT: If the failed drive is not part of a fault-tolerant drive array, you can lose some or all of the data on the failed drive. RAID level 0 does not provide fault tolerance.

With RAID employed, the effects of replacing a drive are felt only by the storage subsystem. The operating system and Oracle8*i* are unaware of the activity. You do not need to power off the cluster components to replace a failed drive.

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To replace a failed drive in a storage subsystem:

1. Identify the failed drive by typing the following CLI command and pressing **Enter:**

   show failedset

   The command returns the name of the failed disk drive.

2. Before physically removing the failed drive, delete the drive from the failedset by typing the following CLI command and pressing **Enter:**

   delete failedset *diskname*

3. Follow the instructions in the Compaq StorageWorks documentation to remove the failed drive and to install a new drive.

4. Enable Autospare by typing the following CLI command and pressing **Enter:**

   set failedset autospare *diskname*

   The array controller automatically initializes the new drive and places it into the spareset. As soon as it becomes a member of the spareset, the array controller uses the new drive to restore the reduced RAIDset or mirrorset.

Replacing a Host Adapter

Before replacing a host adapter, make sure the problem is with the host adapter and not with any of the device drivers.

Determining a Host Adapter Problem

If the System log event information indicates a problem with a host adapter, the problem may be with a device driver or a with the host adapter itself. To identify the source of the problem and fix it, do the following:

1. From the Device Manager, open the entry **SCSI Adapter and RAID Controllers.**

2. Confirm that there are no red or yellow marks next to entry **Compaq CPKGPSA-*xx*, PCI-Fibre Channel HBAs.**

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3. If the driver is not started, reinstall the driver and restart the server when prompted.
4. If the System log still reports a problem, then it is probably caused by the host adapter card. Replace the host adapter and restart the server when prompted to do so. See "Replacing a Failed Host Adapter" for guidelines.

Replacing a Failed Host Adapter

To replace a failed host adapter in a cluster node:

1. Shut down the Oracle instance on the node.
2. Shut down the Oracle services running on the node.
3. Shut down the server.
4. Power off the node.

   NOTE: The KGPSA-BC Host Adapter is not hot swappable, so the node must be completely shut down and powered off before removing and replacing this host adapter.

5. Disconnect the Fibre Channel cable installed between the failed host adapter and its Storage Hub or Fibre Channel SAN Switch.
6. Remove the failed host adapter and insert a new one.
7. Power up the node and run the System Configuration Utility. Take the default settings for the host adapter and save them. Restart the node when prompted.
8. From the Device Manager, open the entry **SCSI Adapter and RAID Controllers** and verify that the Compaq KGPSA device driver is started. If it is not started, reload the driver.
9. Connect the new host adapter by Fibre Channel cable to its Storage Hub or Fibre Channel SAN Switch.

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10. From CLI, use the **Rename** command to rename the connections between the host adapter and the ports on each storage subsystem array controller. When you replaced the host adapter, the connection names you defined were replaced by default connection names for the new host adapter.

    For example, if you have one storage subsystem, there is a connection between the host adapter and the two ports on each of two array controllers. If you followed the recommendations for naming the connections for the old host adapter, they were SVR1TOP1 (node 1, top controller, port 1), SVR1TOP2, SVR1BOT1, and SVR1BOT2.

    To rename the default connection names for the new host adapter using the connections you previously defined for the old host adapter, you would enter:

    Rename *defaultname* SVR1TOP1

    Rename *defaultname* SVR1TOP2

    Rename *defaultname* SVR1BOT1

    Rename *defaultname* SVR1BOT2

11. If you have configured the I/O paths for dual redundancy, make sure that the offsets defined for the connections between the host adapter and port 2 on each array controller are the same as offsets you defined when the storageset was originally configured.

    NOTE: If you have configured the I/O paths for quad redundancy, skip this step (no offsets are defined).

12. Restart the node.

13. Using Disk Management, verify that the storageset configuration seen from the node in which the host adapter was replaced is the same as the configuration seen from other nodes in the cluster.

14. Start the Oracle services and Oracle instance on the cluster node.

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Adding a Shared Storage Subsystem

Each MA8000/EMA12000 Storage Subsystem consists of a controller enclosure and up to six disk enclosures. The procedure to add another MA8000/EMA12000 Storage Subsystem to a redundant Fibre Channel Fabric or redundant FC-AL is very similar to the procedure used for installing the first storage subsystem.

The majority of the instructions to add a storage subsystem are found in the following subsections of Chapter 5, "Installation and Configuration":

- "Installing the Hardware"
- "Setting Up and Configuring an MA8000/EMA12000 Storage Subsystem"

Before starting the activities shown in these subsections, you should shut down the Oracle instance on each node, stop the Oracle services on each node, shut down eacb node, and power off the servers and storage subsystems.

After you have configured the new storage subsystem, you need to make the additional space available to Oracle by performing the necessary Oracle commands to associate the new data files to the database. Perform the necessary Oracle commands to associate the new data files to the database. Refer to the documentation provided with the Oracle software for detailed guidelines.

Replacing a Cluster Node

Before replacing a node, verify that the new configuration is supported by the PDC/O5000. To determine if your new server is supported, see the *Compaq Parallel Database Cluster Model PDC/O5000 Certification Matrix for Windows 2000* at

www.compaq.com/solutions/enterprise/ha-pdc.html

IMPORTANT: Certain restrictions apply to the server models and server configurations that are supported by the Compaq Parallel Database Cluster. For a current list of PDC/O5000-certified servers and details on supported configurations, refer to the *Compaq Parallel Database Cluster Model PDC/D5000 Certification Matrix for Windows 2000.*

Replacing a node consists of removing it logically from the cluster, removing it physically from the cluster, then adding a new server to take its place.

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Removing the Node

1. Record pertinent information that will be needed when configuring the replacement node. This information includes:
   - The IP address and network name of the client LAN adapters
   - For an Ethernet cluster interconnect, the IP address and network name of the Ethernet cluster interconnect adapters
2. If the new node will use applications or data that is stored locally on the node being replaced, back up that data to a removable storage medium or to a remote file server that can be restored onto the replacement node.
3. Stop the Oracle instance on the node to be removed.
4. Stop all Oracle services on the node to be removed.
5. Shut down the server on that node and power it off.
6. Disconnect the Fibre Channel cables between the evicted node and the Storage Hubs or Fibre Channel SAN Switches.
7. Disconnect the cluster interconnect cables from the evicted node and label them as the cluster interconnect cables.
8. Disconnect the client LAN cables from the evicted node and label them as the client LAN cables.
9. If adapters from the evicted node will be used in the new node, move the adapters to the new node.

Adding the Replacement Node

Adding the replacement node involves the following activities:

- Preparing the replacement node
- Installing the cluster software

NOTE: These subsections contain a high-level outline of the steps to follow. If you need detailed instructions you should read through Chapter 5, "Installation and Configuration."

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Preparing the Replacement Node

Several steps should be performed on the replacement server before it is integrated into the cluster.

Prior to integrating the server into the cluster, perform the following steps:

1. Connect the replacement server to the cluster interconnect and to the client LAN. Power on the server. Although physically connected to the cluster, the server is not yet integrated into the cluster.

   IMPORTANT: Do not connect the server to the Storage Hubs or Fibre Channel SAN Switches yet.

2. Start the replacement node with the Compaq SmartStart and Support Software CD in the CD-ROM drive.
3. Use the Compaq System Configuration Utility to configure the hardware settings of the node and its adapters.
4. Use the Compaq Array Configuration Utility to configure the node's local non-shared disks with RAID.
5. Install and configure Windows 2000 Advanced Server with Service Pack 1 or later.
6. Install necessary Compaq drivers and utilities from the Compaq SmartStart and Support Software CD.
7. Enter unique IP addresses and node names for each node in the hosts and lmhosts files located at %SystemRoot%\system32\drivers\etc.
8. Install the host adapter drivers.
9. Install the Fibre Channel Software Setup (FCSS) utility.
10. Install and configure Secure Path for Windows 2000.

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11. Using Fibre Channel cables, connect the host adapters in the replacement node to the appropriate Storage Hubs or Fibre Channel SAN Switches.

12. If, in the process of replacing the node, you have also replaced the host adapters, do the following for each new host adapter:

    a. Using the **Rename** CLI command, rename the connections between the host adapter and the ports on each storage subsystem array controller. When you replaced the host adapter, the connection names you defined were replaced by default connection names for the new host adapter.

       For example, if you have one storage subsystem, there is a connection between the host adapter and the two ports on each of two array controllers. If you followed the recommendations for naming the connections for the old host adapter, they were SVR1TOP1 (node 1, top controller, port 1), SVR1TOP2, SVR1BOT1, and SVR1BOT2.

       To rename the default connection names for the new host adapter using the connections you previously defined for the old host adapter, you would enter:

       Rename *defaultname* SVR1TOP1

       Rename *defaultname* SVR1TOP2

       Rename *defaultname* SVR1BOT1

       Rename *defaultname* SVR1BOT2

    b. If the I/O paths are configured for dual redundancy, make sure that the offsets defined for the connections between the host adapter and port 2 on each array controller are the same as the offsets you defined when the storageset was originally configured.

NOTE: If the I/O paths are configured for quad redundancy, skip this step (no offsets are defined).

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13. Restart the replacement node.
14. Verify Ethernet connectivity between the replacement node and the existing cluster nodes. Run the ping utility from the replacement node, pinging the client LAN adapters on all other nodes. If Ethernet is used as the cluster interconnect, ping the cluster interconnect adapters of all other nodes.
15. Verify that the replacement node can access the shared storage. From the replacement node, start Disk Management to verify that the same shared disk resources are seen from this node as they are from other installed nodes in the cluster.

Installing the Cluster Software

Now that the replacment node is configured and physically connected to the cluster, the next procedure is to integrate the node into the cluster. This involves installing the low-level cluster management software and the OSDs. It also involves installing the application-level cluster software, including Oracle8*i* Server with the Oracle8*i* Parallel Server Option.

All activities in this procedure are facilitated with the Oracle Universal Installer (OUI). The installation is further simplified in that almost all steps are performed from a single server, the primary cluster node.

To replace a cluster node, you must disassemble the existing cluster and then reform it to include the replacement node.

1. If the replacement node is **not** the node on which you originally installed the OSDs, do the following on all original cluster nodes (not the replacement node):
   a. Shut down the Oracle instance.
   b. Stop all Oracle services.
   c. On the node that was originally used to install the OSDs, use the OUI to deinstall the OSDs.
   d. Restart all nodes to complete the deinstallation process.

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2. If the replacement node is the node on which you originally installed the OSDs, do the following on all nodes:
   a. Shut down the Oracle instance.
   b. Stop all Oracle services.
   c. Uninstall the OSDs from each node by running uninstallOSD, located in the Utilities directory of the installation CD.
   d. Restart all nodes to complete the deinstallation process.
3. Use the OUI to reinstall the OSDs on each cluster node, including the original nodes and the replacement node.
4. Restart each cluster node to complete the OSD installation process.
5. Verify that Object Link Manager has been installed on the replacement node.
6. Install Oracle8*i* Server with the Oracle8*i* Parallel Server Option on the replacement node.
7. Restart the replacement node which, upon restart, is now fully integrated into the cluster.
8. At this point, all further operations are specific to Oracle configuration. Refer to the Oracle setup and configuration documentation for information on configuring Oracle software.

Adding a Cluster Node

Before adding a node, verify that the new configuration is supported by the PDC/O5000. For a complete list of servers supported by the PDC/O5000, see the *Compaq Parallel Database Cluster Model PDC/O5000 Certification Matrix for Windows 2000* at

www.compaq.com/solutions/enterprise/ha-pdc.html

IMPORTANT: Certain restrictions apply to the server models and server configurations that are supported by the Compaq Parallel Database Cluster. For a current list of PDC/O5000-certified servers and details on supported configurations, refer to the *Compaq Parallel Database Cluster Model PDC/D5000 Certification Matrix for Windows 2000.*

During the life of the PDC/O5000, you might need to add a new node to the cluster. A desire to increase performance or throughput can drive this decision. Adding another node also can increase overall availability of the system.

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This can be a time-consuming and complex procedure. Be sure to read through all of the following directions as well as those in the Oracle documentation before starting.

Adding a new node involves the following activities:

- Preparing the new node
- Preparing the existing cluster nodes
- Installing the cluster software

These subsections contain a high-level outline of the steps to follow. If you need detailed instructions you should read Chapter 5, "Installation and Configuration."

Preparing the New Node

To minimize downtime of the cluster, several preparation steps should be performed on the new node before it is integrated into the cluster.

Prior to integrating the new node into the cluster, perform the following steps:

1. Connect the server for the new node to the cluster interconnect and to the client LAN. Power on the new node. Although physically connected to the cluster, the server is not yet integrated into the cluster.

   IMPORTANT: Do not connect the server to the Storage Hubs or Fibre Channel SAN Switches yet.

2. Start the new node with the Compaq SmartStart and Support Software CD in the CD-ROM drive.
3. Use the Compaq System Configuration Utility to configure the hardware settings of the node and its adapters.
4. Use the Compaq Array Configuration Utility to configure the node's local non-shared disks with RAID.
5. Install and configure Windows 2000 Advanced Server with Service Pack 1 or later (whichever is installed on the other nodes).
6. Install necessary Compaq drivers and utilities from the Compaq SmartStart and Support Software CD.
7. Enter unique IP addresses and node names for each node in the hosts and lmhosts files located at %SystemRoot%\system32\drivers\etc.

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8. Install the host adapter drivers.
9. Install the FCSS utility.
10. Install and configure Secure Path for Windows 2000.
11. Using Fibre Channel cables, connect the host adapters in the new node to the correct Storage Hubs or Fibre Channel SAN Switches.
12. From CLI, use the **Rename** command to rename the connections between the host adapter and the ports on each storage subsystem array controller. When you replaced the host adapter, the connection names you defined were replaced by default connection names for the new host adapter.

    For example, if you have one storage subsystem, there is a connection between the host adapter and the two ports on each of two array controllers. If you followed the recommendations for naming the connections for the old host adapter, they were SVR1TOP1 (node 1, top controller, port 1), SVR1TOP2, SVR1BOT1, and SVR1BOT2.

    To rename the default connection names for the new host adapter using the connections you previously defined for the old host adapter, you would enter:

    Rename *defaultname* SVR1TOP1

    Rename *defaultname* SVR1TOP2

    Rename *defaultname* SVR1BOT1

    Rename *defaultname* SVR1BOT2
13. If the I/O paths are configured for dual redundancy, make sure that the offsets defined for the connections between the host adapter and port 2 on each array controller are the same as the offsets you defined when the storageset was originally configured.

    NOTE: If the I/O paths are configured for quad redundancy, skip this step (no offsets are defined).

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14. Restart the new node.
15. Verify Ethernet connectivity between the new node and the existing cluster nodes. Run the ping utility from the replacement node, pinging the client LAN adapters on all other nodes. If Ethernet is used as the cluster interconnect, ping the cluster interconnect adapters of all other nodes.
16. Verify that the new node can access the shared storage. From the new node, start Disk Management to verify that the same shared disk resources are seen from this node as they are from other installed nodes in the cluster.

Preparing the Existing Cluster Nodes

To prepare the existing cluster nodes for adding a new node, add the unique IP addresses and node names for the new node in the hosts and lmhosts files of each existing cluster node. These files are located at %SystemRoot%\system32\drivers\etc.

Verify TCP/IP connectivity between the new node and the existing cluster nodes. Run the ping utility from the new node, pinging the client LAN adapters on all other nodes. If Ethernet is used as the cluster interconnect, ping the cluster interconnect adapters of all other nodes.

Installing the Cluster Software

Now that the new node is configured and physically connected to the cluster, the next procedure is to integrate the node into the cluster. This involves installing the low-level cluster management software and the OSDs. It also involves installing the application-level cluster software, including Oracle8*i* Server with the Oracle8*i* Parallel Server Option.

The cluster must be brought offline to install the cluster software. Because the database will be unavailable while configuring the Oracle software, it is recommended that this procedure be performed during non-peak work hours.

NOTE: As a precaution, it is recommended that you back up the database.

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To install the cluster software, perform the following steps:

1. To add a node to the cluster, you must disassemble the existing cluster and then reform it to include the new node. Do the following on all original cluster nodes (not the new node):
   a. Shut down the Oracle instance.
   b. Stop all Oracle services.
   c. Deinstall the OSDs by running the OUI on the node on which the OUI was originally run.
   d. Restart all node to complete the deinstallation process.
2. Reinstall the OSDs using the OUI on the installing node.

   NOTE: When prompted for the names of the nodes, specify the original nodes and the new node.

3. Verify that Object Link Manager is installed on the new node.
4. Restart original nodes to complete the OSD installation process.
5. Start the OracleCMService on each cluster node.
6. Install Oracle8*i* Server with the Oracle8*i* Parallel Server Option by using the OUI on the new node. Select only the new node name when asked which node to install the software on. See the *Oracle8i Parallel Server Setup and Configuration Guide* for details on installing and configuring the Oracle software.
7. Once the configuration of the Oracle software is complete, start the Oracle services and Oracle instances on each cluster node.

   NOTE: The addition of an Oracle instance that runs on the new node requires the creation of two additional database log files and additional rollback segments to the database.

   After the new partitions are created for the log files and rollback segments, use the Object Link Manager GUI to set the symbolic link to the log files and rollback segments.

   NOTE: It is recommended that each node in the cluster be rebooted to ensure that new partitions on the shared storage can be seen by all nodes.

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Monitoring Cluster Performance

Tools Overview

Several tools exist to monitor performance of your cluster. Use the tools to regularly monitor the performance of each node and each Oracle instance. The gathered information might identify a disparity in the workload being performed by each node, which signifies a need to adjust the distribution of the workload so that the overall cluster performance is maximized.

- Compaq Insight Manager can be used to gather low-level, in-depth hardware statistics for the server and networking hardware components used in the cluster.
- Secure Path Manager is used to manage redundant I/O paths to MA8000/EMA8000 Storage Subsystems. Secure Path Manager displays a graphical representation of the current multiple path environment and indicates the location and state of all configured storage units on each of the paths.
- StorageWorks Command Console (SWCC) gathers hardware statistics for the storage subsystem components.
- Windows 2000 Performance Monitor gathers performance characteristics of many *objects*. Examples of monitored *objects* are memory, processor, hard drive performance, network software, and application software.
- Oracle8*i* Performance Manager captures, computes, and presents performance data about the Oracle database. Specific data about Oracle8*i* Parallel Server metrics are monitored and viewed with this application.

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Using Secure Path Manager

StorageWorks Secure Path is a high availability software product that provides continuous data access for MA8000/EMA12000 Storage Subsystems. Redundant hardware, advanced RAID technology, and automated failover capability are used to enhance fault tolerance and availability. Secure Path, in conjunction with your MA8000/EMA12000 Storage Subsystem, effectively eliminates as single points of failure in the storage system, the array controllers, disk drives, interconnect hardware, and host adapters.

NOTE: This section assumes that storagesets have already been configured, using SWCC or CLI, and that the drives have been partitioned with Disk Management.

Secure Path Manager is the cluster management component of Secure Path. Secure Path Manager provides a Graphical User Interface (GUI) utility that:

- Reports the status of the I/O paths in each redundant FC-AL or redundant Fibre Channel Fabric.
- Reports disk status (path assignment, failover, and failback activity).
- Enables automatic drive failback upon path restoration.

It is recommended that Secure Path Manager GUI remain active (or minimized) to provide continuous Secure Path status monitoring.

IMPORTANT: If you make changes to the Secure Path Agent Configuration, the changes will not go into effect until you stop and restart the Secure Path Agent Service from the **Services** screen.

NOTE: If Secure Path Manager shows a controller failure, be sure you match the displayed failed controller with the correct physical controller. The Secure Path Manager GUI displays the array controllers in each storage subsystem according to their serial numbers, not according to their physical order: the array controller with the lower serial number is displayed as Controller A and the array controller with the higher serial number is displayed as Controller B, regardless of their actual physical order in the controller enclosure. You can display a controller's serial number by using the **show this_controller** CLI command.

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Monitoring Storage Systems

The Storage System View of Secure Path Manager displays each storage subsystem, array controllers, and associated storagesets. When you highlight a storageset in Storage System View, Secure Path Manager displays information about the physical I/O paths from each node to that storageset. The following information is displayed for each path:

- The Secure Path host system (node) that has an established access patb to the storageset.
- The array controller servicing the path.
- The physical port number of the host adapter servicing the path. This is a relative number determined by Windows 2000's order of discovery for host adapters on that node.
- The physical Bus, Target, and LUN number describing the path address for the storageset.
- A user-selectable Path Mode parameter that specifies path behavior during nominal and failure conditions. Path Mode may be set to Preferred, Alternate, Pre-Offline (Preferred and Offline), or Alt-Offline (Alternate and Offline).
- A set of State attributes that describe the current operational condition of the path. Paths may exist in Active, Failed, or Available states.

Manipulating Storagesets and I/O Paths

You can use Secure Path Manager to perform the following actions on the storagesets and I/O paths that are managed by Secure Path Manager:

- Move a storageset from one array controller to another. Use this action when you want to change the ownership of a storageset from one array controller to the other.
- Make an I/O path Alternate. Use this action when you have Load Distribution enabled and you want to disable I/O operations to one or more I/O paths.
- Make an I/O path Preferred. Use this action when you have Load Distribution enabled and you want to re-enable I/O operations to a path that you have previously disabled.
- Change the Preferred I/O path. Use this action when Load Distribution is disabled, there are multiple I/O paths available to a storageset on the same controller and you wish to select a new Preferred Path for normal I/O operations.

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- Make an I/O path Offline. Use this action when you want to prevent that path from being used for any I/O operations under any circumstances.
- Make an I/O path Online. Use this action when you want to return a path that is currently in the "Alt-Offline" or "Pre-Offline" mode to its original mode.
- Verify an I/O path. Use this action when you want Secure Path Manager to determine the current state of a path.
- Repair an I/O path. Use this action when you want Secure Path Manager to restore access to a failed path after the problem has been corrected.

Refer to the Secure Path documentation provided with the Secure Path software for details on performing these operations.

Detecting I/O Path and Array Controller Failures

Secure Path Manager periodically monitors the status of all systems in your storage profile at a rate determined by the Polling Interval storage profile parameter. To indicate failures, icons are used and path states are set to FAILED in the Secure Path Manager GUI. In addition, failover events are logged by the RaiDisk driver in the Event Viewer. The Secure Path Agent also notifies StorageWorks Command Console immediately when a fault is detected.

You should routinely monitor Secure Path Manager status to check for the occurrence of failover events that might compromise either the performance or availability of storage resources.

Note that Secure Path Manager client is not required to be running in order for Secure Path to protect path availability. The RaiDisk device driver running on cluster nodes handles Secure Path's protection capability.

Refer to the Secure Path documentation for descriptions of the icons used to indicate changes in path and controller status.

Identifying I/O Path and Array Controller Failures

The icons and other information in the Secure Path Manager views can help you identify the source of I/O path and array controller failures. See the Secure Path documentation for detailed descriptions of the procedures for performing these activities.

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Uninstalling Secure Path

To remove Secure Path and Fibre Channel software and hardware from your cluster:

1. Open the Control Panel and choose **Add/Remove Programs.**
2. Select **SANWorks Secure Path Server** and click **Add/Remove.**
3. Select **SANWorks Secure Path Client** and click **Add/Remove.**
4. Click **Yes** to stop the Secure Path Agent so that the uninstall can proceed properly.
5. Restart the node.
6. Repeat Steps 1 through 5 for all nodes in the cluster.

NOTE: To aid in the reinstallation of Secure Path, the file "client.ini" is not removed.

The uninstallation process is complete.

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Chapter 7

Troubleshooting

This chapter addresses potential problems you might encounter as you install, configure, test, and operate your Compaq Parallel Database Cluster Model PDC/O5000 (referred to here as the PDC/O5000). This chapter is organized as follows:

- Basic Troubleshooting Tips
- Troubleshooting Oracle*8i* and operating system dependent module (OSD) installation problems and error messages
- Troubleshooting node-to-node connectivity problems
- Troubleshooting client-to-cluster connectivity problems
- Troubleshooting shared storage problems
- Troubleshooting Secure Path

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Basic Troubleshooting Tips

Power

Verify that the cluster nodes, storage subsystems, and Fibre Channel SAN Switches or Storage Hubs for the storage area network (SAN) and the switches or hubs for the cluster interconnect are all powered on.

The correct power-on sequence is:

- Storage subsystems
- Fibre Channel SAN Switches or Storage Hubs (Power is applied to the Storage Hubs when the AC cord is plugged in.)
- Ethernet switches/hubs
- ProLiant servers

NOTE: The Storage Hubs and some network hub or switch devices do not have on/off buttons; they receive power when the power cord is plugged in. The Fibre Channel SAN Switches have on/off buttons.

Physical Connections

Verify that all cable connections between the following components are properly made. Where redundant connections exist, be sure that the redundant paths are cabled correctly between:

- Cluster nodes and the cluster interconnect switches or hubs
- Cluster nodes and the client LAN switches or hubs
- Host adapters in the cluster nodes and the Fibre Channel SAN Switches or Storage Hubs
- Fibre Channel SAN Switches or Storage Hubs and the array controllers installed in each storage subsystem

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Access to Cluster Components

Once the physical connections have been checked, ensure that communication is occurring between all the cluster components.

- To test the Ethernet cluster interconnect and client LAN connections, use the ping utility. From eacb cluster node, ping the Ethernet cluster interconnect adapter or port located in the other nodes. Similarly, from each cluster node, ping the name, then the address, of the client LAN Ethernet adapter or port located in the other nodes. A correct ping response from each node confirms that the Ethernet connections are correct. For information about using the ping utility, see "Verifying the Hardware and Software Installation" in Chapter 5, "Installation and Configuration."
- To confirm that the shared storage is accessible to each cluster node, run Secure Path Manager or Disk Management from each node. Confirm that the same shared disk volumes can be seen from each node. If the shared storage resources are not consistent across all nodes, refer to Appendix A, "Diagnosing and Resolving Shared Disk Problems," for more details.

Software Revisions

The following software components must have the same revision level on each of the cluster nodes:

- Oracle8*i* Server with Oracle8*i* Parallel Server Option
- MA8000/EMA12000 Storage Subsystem drivers
- Compaq Insight Manager
- Compaq Array Configuration Utility
- Compaq Secure Path for Windows 2000
- Compaq Ethernet OSDs
- Cluster interconnect drivers
- Microsoft Windows 2000 Advanced Server with Service Pack 1 or later

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For information about currently supported software revisions for the PDC/O5000, refer to the *Compaq Parallel Database Cluster Model PDC/O5000 Certification Matrix for Windows 2000*. This document is available at

www.compaq.com/solutions/enterprise/ha-pdc.html

Depending on your specific configuration, other software (for example, customer applications such as packet utilities) might exist that should be of the same revision level. If the same software is used on all the cluster nodes and either assists with the cluster's operation or takes advantage of clustering, the revision level should be the same.

Firmware Revisions

The firmware level must be identical for each of the following cluster components:

- The system ROM on each server
- Firmware for the HSG80 Array Controllers

For information about currently supported firmware revisions for the PDC/O5000, refer to the *Compaq Parallel Database Cluster Model PDC/O5000 Certification Matrix for Windows 2000*. This document is available at

www.compaq.com/solutions/enterprise/ha-pdc.html

Depending on your specific configuration, other firmware might exist that must be of the same revision level. A determining factor is whether or not the hardware device is part of a path that is accessible by more than one cluster node, more than one storage subsystem, or more than one client computer. If so, it is required that the firmware level of the hardware devices be identical.

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Troubleshooting Oracle8*i* and OSD Installation Problems and Error Messages

Potential Difficulties Installing the OSDs with the Oracle Universal Installer

- The Oracle Universal Installer (OUI) uses an inventory file to track which components of the OSDs have been installed on each of the cluster nodes. A single inventory file is maintained on the node from which the OUI was initially run. All subsequent uses of the OUI must be made from that same installing node.
- Installing onto a cluster node that already contains some or all of the OSD components will likely result in an incomplete installation. If difficulties persist, contact your support representative for assistance.
- The OUI uses the network connections to transfer files from the primary node to the other cluster nodes. Use the ping utility to ensure that proper node-to-node connectivity exists.
- The OUI requires administrator rights on all cluster nodes. To verify connectivity and access rights for each node, issue the following from the command line on the primary node:

  C: net use *machine_name*\C$ * /User: <*admin_login*>

  in which the "*" results in the system prompting you for a password, and the password is not echoed.

  If successful, the net use command returns:

  "The command completed successfully."

- Determine whether or not you need to deinstall a partial OSD installation. An incomplete installation can result in a partial installation of the OSDs on the cluster. If this occurs, you must clean up after the partial installation (by removing it) before you can successfully run the OUI again. An incomplete OSD installation could result for various reasons, for example:
  - A cable is no longer seated tightly into its connector.
  - The node from which you are running the OUI cannot communicate with all other nodes in the cluster.
  - The user running the OUI does not have administrator privileges on all cluster nodes.

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Refer to "Deinstalling a Partial OSD Installation" in Chapter 6, "Cluster Management," for information about how to remove a partial OSD installation.

Unable to Start OracleCMService

- Verify that the cluster interconnect is properly configured.
- Make sure the OSDs have been properly installed on the nodes by running the OUI on the cluster's primary node. Click **Installed Products** and verify that an entry for the OSDs exists.
- Verify that the OracleCMService has properly started by checking its error log. The default location for the error log is C:\compaq\ops\cmsvr.log. If not found in the default location, look in the same directory in which the OSD modules were installed.
- Verify that the Node Manager Service, OracleNMService, is running. If not, see the error logs in C:\compaq\ops\nm.log. If OracleNMService is running, check the CM Server logs in C:\compaq\ops\cmsrvr.log. Attempt to start the OracleCMService again.
- Check the System log and Applications log for errors.

Unable to Start OracleNMService

- Verify that the OracleNMService has properly started by checking the error log. The default location for the error log is C:\compaq\ops\nm.log. If not found in the default location, look in the same directory in which the OSD modules were installed.
- Verify that Oracle8*i* software is correctly installed on all the nodes. Refer to Chapter 5, "Installation and Configuration" for an overview of Oracle8*i* software installation. Refer to the documentation provided with the software for detailed installation instructions.
- Verify the connections and accessibility of the cluster components. Refer to the "Basic Troubleshooting Tips" section in this chapter.
- Check the Windows 2000 Advanced Server event log for errors. Be sure to check both the System and Application logs.

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Unable to Start the Database

- Verify that Object Link Manager is properly installed and running on each node. Also, verify that Object Link Manager accurately sees all of the Oracle partitions and their symbolic link associations. Refer to Appendix A, "Diagnosing and Resolving Shared Disk Problems" for detailed guidelines.
- Verify that all files created by Net8 Config Assistant were transferred properly to eacb respective node.
- Verify the connections and accessibility of the cluster components. Refer to the "Basic Troubleshooting Tips" section in this chapter.
- Verify that the OracleService is running. From the **Services** screen, scan the list of services and check to see if the OracleService is started.
- Verify that the database links are properly set up on all nodes and that correct entries exist for all datafiles, including OPS_CMDISK. Refer to the *Oracle8i Parallel Server Setup and Configuration Guide* for further details.

Initialization of the Dynamic Link Library NM.DLL Failed

If this failure occurs, stop the currently running OracleCMService and OracleNMService. Restart the OracleNMService, then the OracleCMService. From the **Services** screen, locate each service, highlight it, then stop it. Finally, highlight the service and restart it.

Troubleshooting Node-to-Node Connectivity Problems

Nodes Are Unable to Communicate with Each Other

- Check the System log and Applications log for errors.
- Check the OracleCMService error log for information. The default location for the error log is C:\compaq\ops\cmsrvr.log. If not found in the default location, look in the same directory in which the OSDs were installed.
- Verify the connections and accessibility of the cluster components. Refer to the "Basic Troubleshooting Tips" section in this chapter.

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- The cluster interconnect must be on a separate subnet than the client LAN. Check this by viewing the IP addresses assigned to all interconnect adapters and to all client LAN adapters.
- If Compaq Insight Manager is loaded and configured, use it to check the operation statistics and possible error messages for the interconnect adapter installed in each cluster node.

When Using the Ethernet Cluster Interconnect

- Make sure that the Ethernet cluster interconnect components (adapters, cables, switches or hubs) are properly installed as specified in Chapter 5, "Installation and Configuration."
- Make sure that the Ethernet cluster interconnect and the client LAN are connected to different Ethernet switches or hubs.
- Use the ping utility to test the Ethernet cluster interconnect connections. For information about the ping utility, refer to "Verifying Cluster Communications" in Chapter 5, "Installation and Configuration."
- Make sure that all Ethernet traffic not related to the Oracle data is using the client LAN, not the cluster interconnect.

Unable to Ping the Cluster Interconnect or the Client LAN

If you are using the recommended method of using static IP addresses, ensure that the hosts file and lmhosts files are properly set up.

When Using the Ethernet Cluster Interconnect

- Make sure that the Ethernet cables are properly connected and that the Ethernet switches or hubs are powered on. In the redundant Ethernet cluster interconnect, verify that all Ethernet adapters used as the primary cluster interconnect path are connected to the same switch and that all adapters used as the redundant cluster interconnect path are connected to the redundant switch.
- Make sure that the Ethernet drivers are properly installed and configured on the cluster nodes. Verify the Ethernet drivers for the interconnect adapters are the same revision level on all cluster nodes.

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- If you are using two dual-port Ethernet adapters in each node to connect to both the client LAN and the Ethernet cluster interconnect, make sure that the cables are installed between the correct adapter ports and switches.
- Make sure the OSDs have been properly installed on the affected node or nodes by running the OUI on the cluster's primary node. Click **Installed Products** and verify that an entry for the OSDs exists.
- Make sure the OracleCMService and all other Oracle services have started without error. From the **Services** screen, check to see if the services have started. From the Event Viewer, check the Applications log for error messages about the Oracle services.
- Run Object Link Manager from each node to verify that the Oracle partitions and symbolic link associations are accurately displayed.
- Verify that the node or nodes have access to the shared storage. Run Disk Management and make sure that all the shared disk resources appear as expected. If the view is not consistent across all cluster nodes, refer to Appendix A, "Diagnosing and Resolving Shared Disk Problems."

Troubleshooting Client-to-Cluster Connectivity Problems

A Network Client Cannot Communicate With the Cluster

- Verify that the user ID has sufficient rights to perform the desired action.
- Make sure proper network connectivity exists by verifying that the connections from the network client to the cluster are cabled correctly. Additionally, verify that the network routers/switches/hubs used in the client LAN are powered on and properly cabled.
- Make sure that pinging an IP address over the client LAN from a client to the cluster issues a correct reply. Perform ping testing as described under "Verifying Cluster Communications" in Chapter 5, "Installation and Configuration."
- Make sure that the TNSNames.ora file is properly configured on client and cluster nodes as defined by the Oracle Net8 Config Assistant utility.

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- Make sure that the Oracle TNSListener is running on the cluster nodes. From the **Services** screen, verify that it is started.
- Make sure that the Oracle Listener files are set up on the cluster nodes by using the Oracle TNSPing utility.
- Run the Object Link Manager GUI from each node to verify correct Oracle partitions and symbolic link associations. Refer to Appendix A, "Diagnosing and Resolving Shared Disk Problems," for more details.

Troubleshooting Shared Storage Subsystem Problems

Verifying Host Adapter Device Driver Installation

This section addresses potential problems arising from the use of the MA8000/EMA12000 Storage Subsystem as the shared storage device. This section does not address storage subsystem problems that are specific to the MA8000/EMA12000 Storage Subsystem itself or to the use of the storage subsystem in a standalone server configuration. For detailed coverage of those issues, refer to the Compaq StorageWorks documentation provided with the MA8000/EMA12000 Storage Subsystem.

Verifying KGPSA-BC Device Driver Initialization

A problem with the Windows 2000 HAL (Hardware Abstraction Layer) may prevent the KGPSA-BC Host Adapter device driver (LP6NDS35.SYS) from initializing during system boot. The consequences of this problem are:

- None of the shared storage subsystem devices connected to the affected KGPSA-BC Host Adapter will be available.
- The event log entry will be entered in the system event log. The generic message "At least one service or driver failed during system setup" is displayed.

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To fix this problem, first do the following:

1. From the Event Viewer, locate the event log entry marked **CPQKGPSA** to find the host adapter device driver errors.
2. Restart the server.
3. If the driver error message persists, reinstall the KGPSA-BC Host Adapter device driver.

If the problem is caused by the Windows 2000 HAL reconfiguring the KGPSA-BC Host Adapter with conflicting resources, perform the following workaround. This workaround causes the HAL to use the BIOS-assigned defaults and not to reassign PCI resources.

1. Use Notepad or Edit to edit the BOOT.INI file as follows:
   a. Remove the read-only file attribute (for example, attrib -r -h -s c:\boot.ini).
   b. Add the /PCILOCK option to the system boot entry.
   c. Reapply the read-only file attribute that was undone in Step 1a.

   Example:

   ```
   [boot loader]
   timeout=30
   default=multi(0)disk(0)rdisk(0)partition(2)\WINNT
   [operating systems]
   multi(0)disk(0)rdisk(0)partition(2)\WINNT="Microsoft Windows 2000 Advanced Server"/pcilock
   ```

2. Restart the affected server.

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Verifying Connectivity to a Redundant Fibre Channel Fabric

Verify that the array controllers and the cluster nodes are properly connected to all paths of the redundant Fibre Channel Fabric as described in this section.

Fibre Channel Fabric Connectivity Guidelines

To ensure that all connections along the Fiber Channel Fabric paths are correct, verify the following:

- KGPSA-BC or KGPSA-CB Host Adapters have been installed in the same slot locations across all cluster nodes.
- For each host adapter pair installed in the server, verify that the upper (or leftmost) host adapter is connected by Fibre Channel cable to one Fibre Channel SAN Switch and that the bottom (or rightmost) host adapter is connected to the second Fibre Channel SAN Switch.
- For the array controller pair installed in each storage subsystem, verify that the two ports on each array controller are connected to different Fibre Channel SAN Switches.
- If an MA8000/EMA12000 Storage Subsystem has three or fewer disk enclosures, verify that a dual-bus I/O module with two SCSI cables is installed in each disk enclosure. Also verify that 14 or fewer disk drive units are installed in each disk enclosure.
- If an MA8000/EMA12000 Storage Subsystem has four to six disk enclosures, verify that a single-bus I/O module with one SCSI cable is installed in each disk enclosure. Also verify that 12 or fewer disk drive units are installed in each disk enclosure.

MA8000/EMA12000 Storage Subsystem Connectivity to Fibre Channel Fabric Connection Paths

To ensure that an array controller is connected to the correct Fibre Channel Fabric path, open a CLI window and issue the CLI command **show this_controller.** If the port 1 topology is in an Offline state, refer to the StorageWorks documentation about the HSG80 Array Controller ACS and CLI for more information about how to configure an MA8000/EMA12000 Storage Subsystem.

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The topology for Port 1 on each array controller should be:

- Fabric Up state (not the Standby state)
- FABRIC

Server Node Connectivity to Fibre Channel Fabric Connection Paths

To verify that your servers are connected to all Fibre Channel Fabric paths, open a CLI window and issue the CLI command **show connection**. The output of this command shows status information about present and previous connections to all Fibre Channel Fabric paths, including connection name, controller, controller port, adapter ID address, status, and unit offset. The status entry indicates the port is Online (connected) or Offline (disconnected).

Rename the connection-name field to reflect the configuration of the array controllers (for example, SVR1TOP1 for node 1, top controller, port 1). This will improve your ability to view the Fibre Channel Fabric connections. For further information about controller properties, see "Setting Up and Configuring an MA8000/EMA12000 Storage Subsystem" in Chapter 5, "Installation and Configuration."

Verifying Connectivity to a Redundant Fibre Channel Arbitrated Loop

Verify that the array controllers and the cluster nodes are properly connected to all paths of the redundant Fibre Channel Arbitrated Loop (FC-AL) as described in this section.

Fibre Channel Arbitrated Loop Connectivity Guidelines

To ensure that all connections along the FC-AL paths are correct, verify the following:

- KGPSA-BC or KGPSA-CB Host Adapters have been installed in the same slot locations across all cluster nodes.
- For each host adapter pair installed in the server, verify that the upper (or leftmost) host adapter is connected by Fibre Channel cable to one Storage Hub and that the bottom (or rightmost) host adapter is connected to the second Storage Hub.

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- For the array controller pair installed in each storage subsystem, verify that the two ports on each array controller are connected to different Storage Hubs.
- If an MA8000/EMA12000 Storage Subsystem has three or fewer disk enclosures, verify that a dual-bus I/O module with two SCSI cables is installed in each disk enclosure. Also verify that 14 or fewer disk drive units are installed in each disk enclosure.
- If an MA8000/EMA12000 Storage Subsystem has four to six disk enclosures, verify that a single-bus I/O module with one SCSI cable is installed in each disk enclosure. Also verify that 12 or fewer disk drive units are installed in each disk enclosure.

MA8000/EMA12000 Storage Subsystem Connectivity to FC-AL Connection Paths

To ensure that an array controller is connected to the correct FC-AL path, open a CLI window and issue the CLI command **show this_controller.** If the port 1 topology is in an Offline state, refer to the StorageWorks documentation about the HSG80 Array Controller ACS and CLI for more information about how to configure an MA8000/EMA12000 Storage Subsystem.

The topology for Port 1 on each array controller should be:

- Loop Up state (not the Standby state)
- LOOP_HARD

Server Node Connectivity to FC-AL Connection Paths

To verify that your servers are connected to all FC-AL paths, open a CLI window and issue the CLI command **show connectionb.** The output of this command shows status information about present and previous connections to all FC-AL paths including connection name, controller, controller port, adapter ID address, status, and unit offset. The status entry indicates the port is Online (connected) or Offline (disconnected).

Rename the connection-name field to reflect the configuration of the array controllers (for example, SVR1TOP1 for node 1, top controller, port 1). This will improve your ability to view the FC-AL connections. For further information about controller properties, see "Setting Up and Configuring an MA8000/EMA12000 Storage Subsystem" in Chapter 5, "Installation and Configuration."

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A Cluster Node Cannot Connect to the Shared Drives

Verify connections and accessibility between the servers, the Fibre Channel SAN Switches or Storage Hubs, and the MA8000/EMA12000 Storage Subsystem controller enclosures. See "Verifying Cluster Communications" in Chapter 5, "Installation and Configuration."

Disk Management Shows Storagesets With the Same Label (Dual Image)

To enhance I/O throughput, both ports (1 and 2) on an HSG80 Array Controller can be configured to different storagesets in the MA8000/EMA12000 Storage Subsystem. If a unit_offset value has not been assigned to port 2 on the array controller, then both port 1 and port 2 will see the same storagesets, as will Disk Management.

To correct this problem, do the following:

- Ensure that the affected array controller is set to multibus_failover mode. Refer to "Verifying Array Controller Properties" in Chapter 5, "Installation and Configuration."
- Ensure that port 2 on the affected array controller has been assigned a unit_offset value. This value ensures that port 2 accesses a different range of storage devices than port 1. Refer to "Verifying Array Controller Properties" in Chapter 5, "Installation and Configuration."

Device or Devices Were Not Found by KGPSA-BC Device Driver

All of the I/O path devices (storagesets) present on one of the I/O paths should be viewable from the SCSI driver entry under the Device Manager. If one or more of these devices cannot be found by the device driver, then you must identify the cause of the problem and correct it.

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To determine whether or not the storagesets can be viewed by a KGPSA-BC device driver, do the following:

1. From the Device Manager, select **SCSI Adapters.**
2. View the list of installed Hard Drives and manually count them. The total number of drives, **excluding the system drives,** should be equal to the number of paths associated with each storageset multiplied by the total number of storagesets configured. For example, if there are 12 LUNs configured with no offsets for an MA8000/EMA12000 Storage Subsystem, then Windows 2000 Advanced Server will have 4 I/O paths to each LUN. The Device Manager should display 48 Hard Drive entries (4*12 = 48).

If one or more of the storage subsystem's storagesets is not displayed, then check the integrity of the I/O path from the host adapter to its Fibre Channel SAN Switch or Storage Hub and out to its array controllers. Do the following:

- Confirm that the KGPSA-BC device driver was properly installed. Refer to "Installing Secure Path Software for Windows 2000" in Chapter 5, "Installation and Configuration."
- From the Secure Path Manager GUI, confirm that all of the I/O paths are visible for each storageset (LUN).
- Check the status LEDs on the host adapter for error indications.
- Use CLI to obtain status information about the array controller. Verify that both port 1 and port 2 are active (for example, that connections are online and that each port was negotiated with its designated FC-AL or Fibre Channel Fabric device ID).

Devices on One I/O Connection Path Cannot Be Seen by the Cluster Nodes

For a Redundant Fibre Channel Fabric

If the cluster node cannot see all of the storagesets that are configured to the Fibre Channel Fabric paths, do the following:

- Verify that the array controllers on the unseen path are set for Multibus_Failover mode. If an array controller has not been set to Multibus_Failover mode, then the cluster nodes will only see the storagesets that are configured to the other array controller in the storage subsystem.

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- If the array controllers have already been set to Multibus_Failover mode, then check the integrity of the components along the unseen Fibre Channel Fabric path. Do the following:
  - Confirm that the Compaq KGPSA device driver was properly installed. Refer to "Installing Secure Path Software for Windows 2000" in Chapter 5, "Installation and Configuration."
  - Check the status LEDs on the host adapter for error indications.
  - Verify that the Fibre Channel cable has been properly installed between the host adapter and its Fibre Channel SAN Switch.
  - Check the status LEDs on the Fibre Channel SAN Switch ports for error indications.
  - Verify that the Fibre Channel cables have been properly installed from the Fibre Channel SAN Switch to both ports on the array controller.
  - Use the CLI to obtain status information about the array controller. Verify that both port 1 and port 2 on each array controller are active.

For a Redundant Fibre Channel Arbitrated Loop

If the cluster node cannot see all of the storagesets that are configured to the FC-AL paths, do the following:

- Verify tbat the array controllers on the unseen patb are set for Multibus_Failover mode. If an array controller has not been set to Multibus_Failover mode, then the cluster nodes will only see the storagesets that are configured to the other array controller in the storage subsystem.
- If the array controllers have already been set to Multibus_Failover mode, then check the integrity of the components along the unseen FC-AL path. Do the following:
  - Confirm that the Compaq KGPSA device driver was properly installed. Refer to "Installing Secure Path Under Windows 2000" in Chapter 5, "Installation and Configuration."
  - Check the status LEDs on the host adapter for error indications.
  - Verify that the Fibre Channel cable has been properly installed between the host adapter and its Storage Hub.
  - Check the status LEDs on the Storage Hub ports for error indications.

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- Verify that the Fibre Channel cables have been properly installed from the Storage Hubs to both ports on the array controller.
- Use the CLI to obtain status information about the array controller. Verify that both port 1 and port 2 on each array controller are active.

Troubleshooting Secure Path

For detailed information about troubleshooting Secure Path, refer to the troubleshooting documentation provided with the Secure Path software.

Secure Path Guidelines for Windows 2000 Advanced Server

The following rules and guidelines apply to the operation of Secure Path software in a PDC/O5000 cluster running Windows 2000 Advanced Server:

- If you install the optional Compaq StorageWorks Large LUN utility on your PDC/O5000 cluster, you can distribute a maximum of 256 LUNs among the four array controller ports in each storage subsystem.
- If you do not install the Large LUN utility, you can distribute a maximum of 16 LUNs among the four array controller ports in each storage subsystem. This 16-LUN restriction is imposed by the Compaq Secure Path software and the MA8000/EMA12000 Storage Subsystems.

IMPORTANT: When offsets are used, always assign LUNs 0-99 to port 1 on each HSG80 Array Controller and assign LUNs 100-199 to port 2.

- If you do not install the optional Large LUN utility on your cluster, there are two accepted methods for distributing LUNs for storagesets:
  - You can distribute eight LUNs between the same-numbered ports on both array controllers so that a total of 16 LUNs are assigned across all four controller ports in each storage subsystem. For example, assign LUNs 0 through 3 to array controller A port 1, LUNs 4 through 7 to array controller B port 1, LUNs 100 through 103 to array controller A port 2, and LUNs 104 through 107 to array controller B port 2. If array controller A fails in multibus failover mode, Secure Path automatically gives controller B control over I/O transfers for LUNs 0-3 on port 1 and LUNs 100-103 on port 2.

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  - ❑ You can distribute eight LUNs across all four array controller ports. For example, assign LUNs 0 and 1 to array controller A port 1, LUNS 2 and 3 to array controller A port 2, LUNS 4 and 5 to array controller B port 1, and LUNs 6 and 7 to array controller B port 2. In this configuration, a single controller port can access all eight LUNs in the event of a path failure on the other three ports.

- If you do install the optional Large LUN utility on your cluster, then you must follow these guidelines:
  - ❑ Do not assign unit offsets to any connections.
  - ❑ Use unit identifiers D0 through D63 for port 1 array controllers and D100 through D163 for port 2 array controllers.
  - ❑ Distribute the LUNs evenly across all four array controller ports.
- There is no support for Windows 2000 dynamic disks.
- Windows NT fault-tolerant driver (for the host-based RAIDsets) cannot not be used in conjunction with Secure Path.
- The same Secure Path Manager password must be used for all of the hosts in a profile.
- Before you change the Secure Path Agent's list of authorized clients or passwords, you must first manually stop the Secure Path Agent. Be sure to restart the Secure Path Agent after the changes have been completed.
- Before you modify device volume labels with the Disk Management, you must first manually stop the Secure Path Agent. After the modifications are competed, restart the Secure Path Agent to view the changes.
- Before you replace an HSG80 Array Controller, you must first shut down the affected node or nodes. After the replacement array controller has been installed, you reboot the affected node or nodes and make sure that the Secure Path Agent is started.

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Secure Path Manager Shows Reversed Locations for Top and Bottom Array Controllers

The Secure Path Manager GUI detects and displays the two HSG80 Array Controllers in each MA8000/EMA12000 Storage Subsystem according to their serial numbers, not their slot assignments. Regardless of their actual slot locations in the controller enclosure, the array controller with the lower serial number is detected first and always displayed as Controller A; the array controller with the higher serial number is always displayed as Controller B.

If Secure Path Manager shows a controller failure, be sure you match the displayed failed controller with the correct physical controller. You can display an array controller's serial number by issuing the CLI **show this_controller** command.

Secure Path Manager Cannot Start With Hosts That Use Hyphenated Host Names

Secure Path Manager (SPM) is unable to start with hosts that use hyphenated host names (for example. *my-host*). Any hyphen indicates a cluster profile member to Secure Path Manager, and DNS will not be able to resolve the name correctly. Hyphenated host file names must be changed to unhyphenated names on all client systems.

To correct host names, add the name of the host without the hyphen to the Host file. Add this name to the client.ini file with the Agent configuration program, and use this name to log in with Secure Path Manager.

Secure Path Manager Is Delayed In Reporting Path Failure Information

Due to extended error checking features present in the Secure Path software, there may be some delay with Secure Path Manager in reporting failed path information.

By default, the **Secure Path Manager** screen is refreshed every 60 seconds. To perform a manual refresh, press the **F5** key.

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The Addition of New LUNs Causes an Error

In a PDC/O5000 cluster running Windows 2000 Advanced Server, the addition of new LUN(s) may cause the Add/Remove Hardware Wizard to display an error upon initializing the LUN(s) and yellow warning indicators to be displayed from the Device Manager.

To cancel these error displays, reboot the affected server node or nodes.

A Configuration of More Than 64 LUNs Prevents the Secure Path Agent From Starting

A configuration of more than 64 LUNs may inhibit the Secure Path Agent from automatically starting. If this occurs, do the following:

1. From the **Services** screen, right click on **Secure Path Agent**.
2. Select **Properties**, then select **Recovery**.
3. Select **Recovery** to restart the Secure Path Agent after the first failure.
4. Click **Apply**, then click **OK.**

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Appendix A

Diagnosing and Resolving Shared Disk Problems

Introduction

When one or more nodes in a Compaq Parallel Database Cluster Model PDC/O5000 (referred to here as the PDC/O5000) cannot properly join the cluster, you need to consider two possible causes:

- A problem related to the shared disk storage in the cluster's MA8000/EMA12000 Storage Subsystems is preventing one or more nodes from accurately viewing or successfully accessing the available shared storage resources.
- A connectivity problem exists either within the cluster interconnect or the client LAN, preventing one or more nodes from communicating with the other nodes or preventing a client from communicating with the cluster.

This appendix describes the procedures you should follow to diagnose and resolve suspected shared disk problems in a PDC/O5000 cluster.

Figure A-1 identifies, in a flowchart format, the sequence of tasks you should perform to diagnose, isolate, and resolve shared disk problems in the PDC/O5000. A detailed description of each task is provided in the following sections of this appendix.

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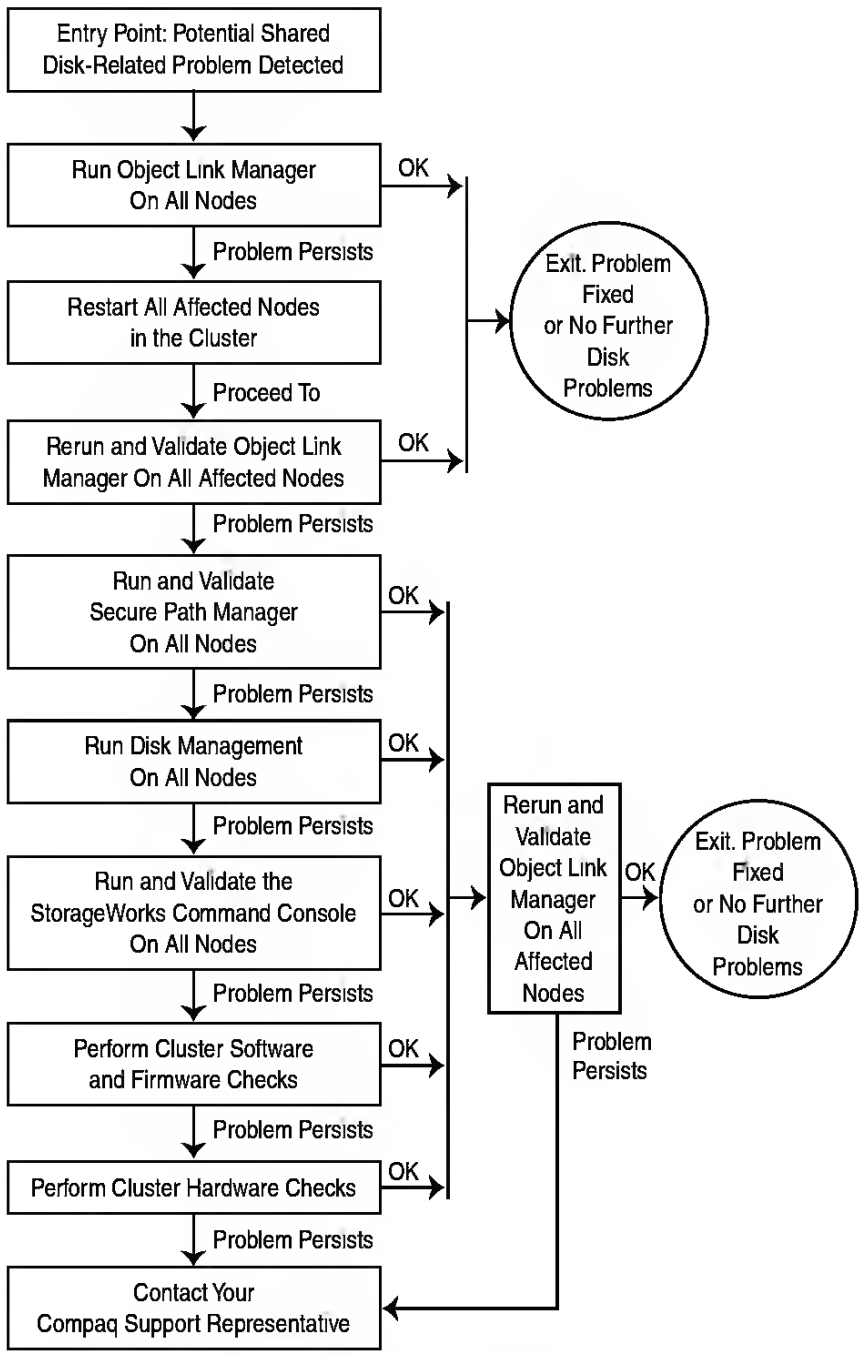
Entry Point: Potential Shared Disk-Related Problem Detected
Run Object Link Manager On All Nodes
OK
Problem Persists
Restart All Affected Nodes in the Cluster
Proceed To
Rerun and Validate Object Link Manager On All Affected Nodes
OK
Problem Persists
Exit. Problem Fixed or No Further Disk Problems
Run and Validate Secure Path Manager On All Nodes
OK
Problem Persists
Run Disk Management On All Nodes
OK
Problem Persists
Run and Validate the StorageWorks Command Console On All Nodes
OK
Problem Persists
Perform Cluster Software and Firmware Checks
OK
Problem Persists
Perform Cluster Hardware Checks
OK
Problem Persists
Contact Your Compaq Support Representative
Rerun and Validate Object Link Manager On All Affected Nodes
OK
Exit. Problem Fixed or No Further Disk Problems
Problem Persists

Figure A-1. Tasks for diagnosing and resolving shared storage problems

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Run Object Link Manager on All Nodes

Object Link Manager simplifies the creation and maintenance of symbolic links between disk partitions and Oracle data files by placing the symbolic link names directly onto the disk partitions, thereby tracking the symbolic links dynamically. This means that if the order in which disk drives are brought online changes, Oracle8*i* Server can find the correct data files and can properly start the Oracle database.

Object Link Manager also provides a detailed view of the Oracle partitions and their symbolic link associations in the cluster's shared storage.

To view the shared storage information from Object Link Manager, perform these tasks:

1. From each node, run the GUI associated with Object Link Manager.
2. Verify that it runs properly and displays no errors.
3. Verify that Object Link Manager can see all Oracle partitions and their symbolic link associations and that this view is consistent across all nodes.
4. Repeat steps 1 through 3 on all other nodes in the cluster.
5. If Object Link Manager does not run properly or displays incorrect Oracle partition and symbolic link information on one or more nodes, proceed to "Restart All Affected Nodes in the Cluster" in this appendix for further instructions.

For instructions on installing and using Object Link Manager, see the readme file:

```
\Object Link Manager\readme.txt
```

This file is located on the Compaq Parallel Database Cluster Clustering Software for Oracle8*i* on Microsoft Windows 2000 CD.

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Restart All Affected Nodes in the Cluster

If Object Link Manager does not run properly on one or more nodes or does not provide consistent information about Oracle partitions and symbolic links from all nodes, perform these steps:

1. Identify the node or nodes on which Object Link Manager either does not run properly or does not present the correct information about Oracle partitions and symbolic links.
2. Restart each affected node.
3. Proceed to "Rerun and Validate Object Link Manager On All Affected Nodes" in this appendix for further instructions.

Rerun and Validate Object Link Manager On All Affected Nodes

Perform these steps from every node on which Object Link Manager does not run properly:

1. Verify that the Object Link Manager service is properly installed on the node. For instructions on installing and using Object Link Manager, refer to this readme file contained on the Compaq Parallel Database Cluster Clustering Software for Oracle8*i* on Microsoft Windows 2000 CD:

   \Object Link Manager\readme.txt
2. Verify that the correct symbolic link names have been used for the shared disk partitions.
3. Restart the Object Link Manager service.
4. Repeat steps 1 through 3 for all nodes in the cluster.

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Run and Validate Secure Path Manager On All Nodes

The **Secure Path Manager** screens provide information about the shared storage resources in the cluster, including MA8000/EMA12000 Storage Subsystem storagesets, array controller path configurations, drive lettering, and volume labels.

To run and validate Secure Path Manager, perform these steps from each node:

1. Use the **Secure Path Manager** screens to verify that every storageset is visible and that all logical disks and HSG80 Array Controllers are correctly and consistently defined across all nodes. Also confirm that the attributes associated with the shared disks are consistent across all nodes. Refer to the documentation provided with the Secure Path software for detailed information about **Secure Path Manager** screens.
2. Verify that the version number for Secure Path Manager is correct. Refer to the *Compaq Parallel Database Cluster Model PDC/O5000 Certification Matrix for Windows 2000* for version information.
3. Verify that Secure Path Manager has been properly installed on the node. Refer to "Installing Secure Path Software for Windows 2000 for the MA8000/EMA12000 Storage Subsystem" in Chapter 5, "Installation and Configuration," for installation instructions.
4. Repeat steps 1 through 3 for all nodes in the cluster.

Run Disk Management On All Nodes

Perform these steps from each node:

1. From Disk Management, verify that the shared storage disks from each MA8000/EMA12000 Storage Subsystem are visible.
2. Verify that all shared drive information (drive letters, volume labels, number of partitions, partition sizes, etc.) is consistent across all nodes.
3. Repeat steps 1 and 2 for all nodes in the cluster.

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Run and Validate the StorageWorks Command Console From All Storage Subsystems

The Compaq StorageWorks Command Console (SWCC), as well as the Command Line Interface (CLI), is used to configure the hardware aspects of the shared disk drives connected to the HSG80 Array Controllers. SWCC and CLI allow you to configure RAID levels and to add or remove physical disk drives or storagesets to a cluster. Like Disk Management and Secure Path Manager, SWCC provides a graphical user interface presentation of the shared storage resources in the cluster.

To run and validate the SWCC from each node, perform these steps:

1. From the SWCC, verify that all shared storage subsystems and their logical disks are visible and consistent across all nodes.
2. Verify that each storage subsystem's serial number for all shared disks is consistent across all nodes.
3. Verify that the RAID configurations of shared disks are consistent across all nodes.
4. Repeat steps 1 through 3 for all nodes in the cluster.

Perform Cluster Software and Firmware Checks

Use the Compaq SmartStart and Support Software CD to perform these checks on the cluster software and firmware:

1. Verify that all necessary drivers have been installed. For example, verify that the correct driver for the host adapter is installed and running on all cluster nodes. Refer to "Installing Secure Path Software for Windows 2000 for the MA8000/EMA12000 Storage Subsystem" in Chapter 5, "Installation and Configuration" for driver installation guidelines.
2. Verify that that the version levels for all drivers, including those for KGPSA-BC or KGPSA-CB Host Adapters and HSG80 Array Controllers, are correct and consistent across all nodes.

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3. Verify that all firmware versions, including those for the system ROM on each server, the host adapter firmware, and array controller firmware, are correct and consistent across all nodes.

NOTE: Refer to the *Compaq Parallel Database Cluster Model PDC/O5000 Certification Matrix for Windows 2000* for information about supported software and firmware versions for this PDC, at

www.compaq.com/solutions/enterprise/ha-pdc.html

Perform Cluster Hardware Checks

Validate the cluster hardware by performing these steps:

1. Determine whether or not hardware errors or communications transport failures might be causing the problem. Use the Event Viewer to verify that no hardware errors or transport problems exist. Check the event log for disk I/O error messages or indications of problems with the communications transport.
2. Determine whether or not the Compaq servers support the physical SCSI disks that are installed in the MA8000/EMA12000 Storage Subsystems. Check the event log for disk I/O error messages or indications of problems with the communications transport.
3. Verify that the indicator lights on the host adapters, Fibre Channel SAN Switches or Storage Hubs, and array controllers all indicate working status.
4. Verify that the Gigabit Interface Converter-Shortwave (GBIC-SW) modules are all the correct brand or model type and are properly seated in the host adapters, Fibre Channel SAN Switches or Storage Hubs, and array controllers.
5. Inspect all Fibre Channel cables to verify that they are in good condition and have no breaks or excessive bends.
6. Verify that the Fibre Channel cables are properly installed and connected to the host adapters, Fibre Channel SAN Switches or Storage Hubs, and array controllers. For details on how to connect the GBIC-SW modules and the Fibre Channel cables, refer to the documentation provided with these hardware products.
7. Verify that all host adapters, array controllers, and shared disk drive modules are properly installed and seated in their receptacles.

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Contact Your Compaq Support Representative

If you are unable to resolve the problem, contact your Compaq support representative for assistance.

In North America, call the Compaq Technical Support Phone Center at 1-800-OK-COMPAQ. Outside North America, call the nearest Compaq Technical Support Phone Center. Telephone numbers for worldwide Technical Support Centers are listed on the Compaq website at

www.compaq.com

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Glossary

Availability	A measure of how well a computer system can deliver services to its clients continuously. Availability is typically expressed as a percentage, with 100 percent being the best possible rating.
Client LAN	A local area network dedicated to servicing requests between network client machines and between the cluster nodes and the client machines. This is different than a cluster interconnect, which is dedicated to servicing information requests to and from only cluster nodes.
Cluster	An integration of software and hardware technologies that enables a set of loosely coupled servers and storage to present a single system image to clients and to operate as a single system. Clustering is a way to improve availability and scalability.
Command Line Interface (CLI)	The interface to the command set used to configure an HSG80 Array Controller and the disk drives to which it is physically and logically connected.
Downtime	The period of time that a computer system is unable to service clients' requests.
Ethernet	A standard network protocol that operates mostly on a physical level, using network interface cards and cabling to transmit data between computers. Transfer rates are normally 10 or 100 megabits per second.

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Fabric	A complex set of interconnections through which there can be multiple and (to the user) unknown paths from point to point. The term "fabric" is used to refer to the X or Y portion of the internal or external network; for example, the X fabric.
Fault tolerance	A characteristic that allows continued operation of a computer entity when a fault (or failure) is encountered. Fault tolerance applies to a computer component, an individual computer, or a cluster of computers, primarily through designing redundant elements into the entity.
FC-AL	See Fibre Channel Arbitrated Loop (FC-AL).
Fibre Channel	An IEEE standard for providing high-speed data transfer among workstations, mainframes, supercomputers, desktop computers, storage devices, and display devices.
Fibre Channel Arbitrated Loop (FC-AL)	A storage area network (SAN) topology that uses FC-AL storage hubs to arbitrate I/O requests between cluster nodes and shared storage resources.
Fibre Channel Fabric	A storage area network (SAN) topology that uses Fibre Channel SAN Switches to connect cluster nodes with shared storage resources.
Fibre Channel Fabric Setup Software (FCSS) utility	Installs the HSZDISK driver and other shared storage subsystem device drivers required for Microsoft Windows 2000 clusters and sets the Arbitrated Loop Physical Address (ALPA) and registry. The FCSS utility is located on the Solutions Software for ACS CD.
Heartbeat	A signal transmitted between cluster nodes to indicate whether the nodes are operating.
High availability	A term used to identify a computer system that can continuously deliver services to its clients 99.9 percent of the time (no more than 8.5 hours of downtime per year).
Hot-pluggable	A computer component that can be removed and replaced without powering down the system.
Hot spare	A computer component that is powered on, not actively processing data, and awaiting a request to take over operation of a failed component.

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Interconnect	A physical connection between cluster nodes that transmits intra-cluster communication, e.g. the cluster heartbeat. The Compaq Parallel Database Cluster interconnect is dedicated to servicing requests only between cluster nodes.
Integrated Distributed Lock Manager	An Oracle software component that coordinates database locks among cluster nodes. Sometimes abbreviated as IDLM.
IP Address	Internet Protocol Address. An address assigned to a network interface card, which computer entities use to locate and communicate with each other. IP addresses can be statically or dynamically assigned.
LAN	Local Area Network.
Large LUN utility	The Compaq StorageWorks Large LUN utility allows PDC/O5000 cluster nodes to access up to 256 LUNs among each storage subsystem's four array controller ports (up to 64 LUNs for each array controller port).
Load balancing	To balance the amount of work (processing) undertaken by each node in a cluster.
Multiple redundant Fibre Channel Arbitrated Loops	The addition of a new redundant Fibre Channel Arbitrated Loop (FC-AL) to a PDC cluster for the purposes of increasing the amount of shared storage space available to the nodes and improving the cluster's I/O performance.
Multiple redundant Fibre Channel Fabrics	The addition of a new redundant Fibre Channel Fabric to a PDC cluster for the purposes of increasing the amount of shared storage space available to the nodes and improving the cluster's I/O performance.
NIC	Network Interface Controller. A board that allows a computer to be connected with a network, and works with the network operating system to control the flow of information over the network.
Node	An individual server in a cluster.
NTFS	New Technology File System. A file organization system by which data is stored and accessed in a Microsoft Windows 2000 operating system.

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Operating System Dependent (OSD) layer	A collection of low-level software modules that monitor critical clustering hardware components and constantly transmit/receive cluster state information to and from Oracle8*i* Parallel Server.
Oracle8*i* Parallel Server Option	A software component that ships as an option of Oracle8*i* Enterprise Edition. The component is responsible for enabling parallel database support. An additional license is required for Oracle8*i* Parallel Server.
POST	Power-On Self-Test. A set of operations executed every time a system is turned on to verity that components are present and operating.
Raw Partition	A disk partition that does not contain file system formatting information. An unformatted partition. Oracle Parallel Server requires its database files to be stored on raw partitions.
RAID	Redundant Array of Inexpensive Disks. A method of using hard disk drives in an array to provide data redundancy to increase system reliability and performance. RAID is categorized into several levels.
Reliability	The continuous integrity of a system (server, storage, network, or cluster).
Resource	A software or hardware entity upon which a client/server application or service is dependent. As it pertains to the Compaq Parallel Database Cluster, a cluster resource must have the ability to be managed by the cluster and must reside on one of the cluster nodes.
Scalability	The ability of a system (server, storage, network, or cluster) to grow or expand in performance, throughput, or capacity.
Secure Path	The Compaq software that provides cluster nodes with continuous data access to MA8000/EMA12000 Storage Subsystem disks drives. Secure Path monitors each I/O path and automatically reroutes I/O to the defined backup path should a failure occur in any component along one path.
Service	A data set or operation set exported by application servers to their clients.
Shared resource	A type of cluster organization in which some resources are accessible to all systems in the cluster.

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Shared storage	A storage system that can be simultaneously accessed by multiple nodes in a PDC cluster. The MA8000/EMA12000 Storage Subsystem is the shared storage subsystem for the PDC/O5000.
Storageset	A group of disk drives configured with RAID techniques to operate as a single container and ensure that every partitioned storageset —whether it uses 10 or 14 physical disk drives—looks like a single storage unit to the cluster nodes.
StorageWorks Command Console (SWCC)	A graphical user interface (GUI) used to create and manage MA8000/EMA12000 Storage Subsystem resources, including hardware RAID implementation, disk mirroring, and disk partitioning.
System	A complete computer system capable of operating independently. A system can be either a single processor system or an SMP system. Example: a server.
UPS	Uninterruptible power supply.

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